# Rio Blanco Oil Shale Company

# Tract C-a



## Modification to the Detailed Development Plan

# LURGI DEMONSTRATION PROJECT

Submitted February 1981 to the
USGS Deputy Conservation Manager-Oil Shale
by Rio Blanco Oil Shale Company



A General Partnership of
Gulf Oil Corporation/Standard Oil Company (Indiana)
2851 South Parker Road, Aurora, Colorado 80014

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## PREFACE

The Rio Blanco Oil Shale Company (RBOSC), a general partnership of Gulf Oil Corporation and Standard Oil Company (Indiana) is the lessee and operator of Federal lease Tract C-a in Rio Blanco County, Colorado (Federal Oil Shale Lease No. C-20046). On September 22, 1977, the Department of the Interior approved RBOSC's plan to demonstrate the feasibility of producing shale oil using a modified in situ (MIS) technology. The approved plan of action also included surface retorting during the Commercial Phase of operations. After obtaining all necessary permits from Federal, State and local agencies, RBOSC began development during a Modular Development Phase (MDP) and is presently in the midst of its MIS demonstration. RBOSC now plans to modify the MDP by also constructing and demonstrating the operation of a Lurgi surface retort after obtaining all required approvals and permits.

This document describing RBOSC's plans for the Lurgi Demonstration Project is being submitted to the Deputy Conservation Manager - Oil Shale (DCM/OS). It contains plans for mining, processing and disposing of the processed shale and describes the required support facilities and operations. In addition, mitigative and management procedures for air, water, reclamation and other environmental areas are discussed. An assessment of anticipated impacts and a monitoring program are also presented.

Other documents which relate to this plan have previously been submitted to the DCM/OS and are on file at the Oil Shale Office (OSO) in Grand Junction, Colorado. These documents include:

- Revised Detailed Development Plan Tract C-a - May 1977
- Final Environmental Baseline Report for Tract C-a and Vicinity - May 1977
- Environmental Monitoring Program Scope of Work, Revision 6.0 (1980)

This document consists of nine sections as shown in the Table of Contents. Section one contains a brief summary of RBOSC's operations since obtaining the lease for Tract C-a in 1974. It also includes an overview of the development plan for the Lurgi Demonstration Project. Sections two through nine provide detailed information for the plan presented. A confidential section, containing RBOSC proprietary information requested by the DCM/OS, has been sent to the OSO under separate cover.

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# Section I

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## 1.1 PROJECT BACKGROUND

A. Tract C-a - The Department of the Interior (DOI) instituted the Prototype Oil Shale Leasing Program in 1974 to encourage development of the Green River oil shale formation. Six leases were offered for sale: Two in Colorado and two in Utah were sold, but two in Wyoming received no bids from industry.

Gulf Oil Corporation and Standard Oil Company (Indiana) were awarded the lease for the first tract in the program, Colorado Tract C-a, after submitting the high bonus bid of $210,305,600. The lease (C-20046) was formally signed by the Colorado State Director of the Bureau of Land Management (BLM) on February 5, and became effective on March 1, 1974.

In order to effectively develop Tract C-a, Gulf and Standard organized the Rio Blanco Oil Shale Project (RBOSP) soon after obtaining the lease. In 1978 the two parent companies formed a general partnership which was renamed the Rio Blanco Oil Shale Company (RBOSC). The sole purpose of RBOSC is to develop Tract C-a.

The tract comprises about 5,100 acres or eight square miles in Rio Blanco County in western Colorado. It is about 20 miles southeast of Rangely and 200 miles west of Denver (see Figure 1-1-1). Total oil reserves on the tract are estimated to be nine billion barrels of which two to five billion barrels can be recovered depending on the method used.

The lease runs for 20 years after the effective date (March 1, 1974), or as long as there is commercial production from the tract, subject to readjustment of terms and conditions at 20-year intervals. Under the provisions of the lease, Gulf and Standard paid $126 million of the bonus bid in three installments, but were allowed to credit $84 million against development expenditures. A royalty will be paid on the oil produced from the tract based on the average value of oil produced in Colorado, Utah and Wyoming.

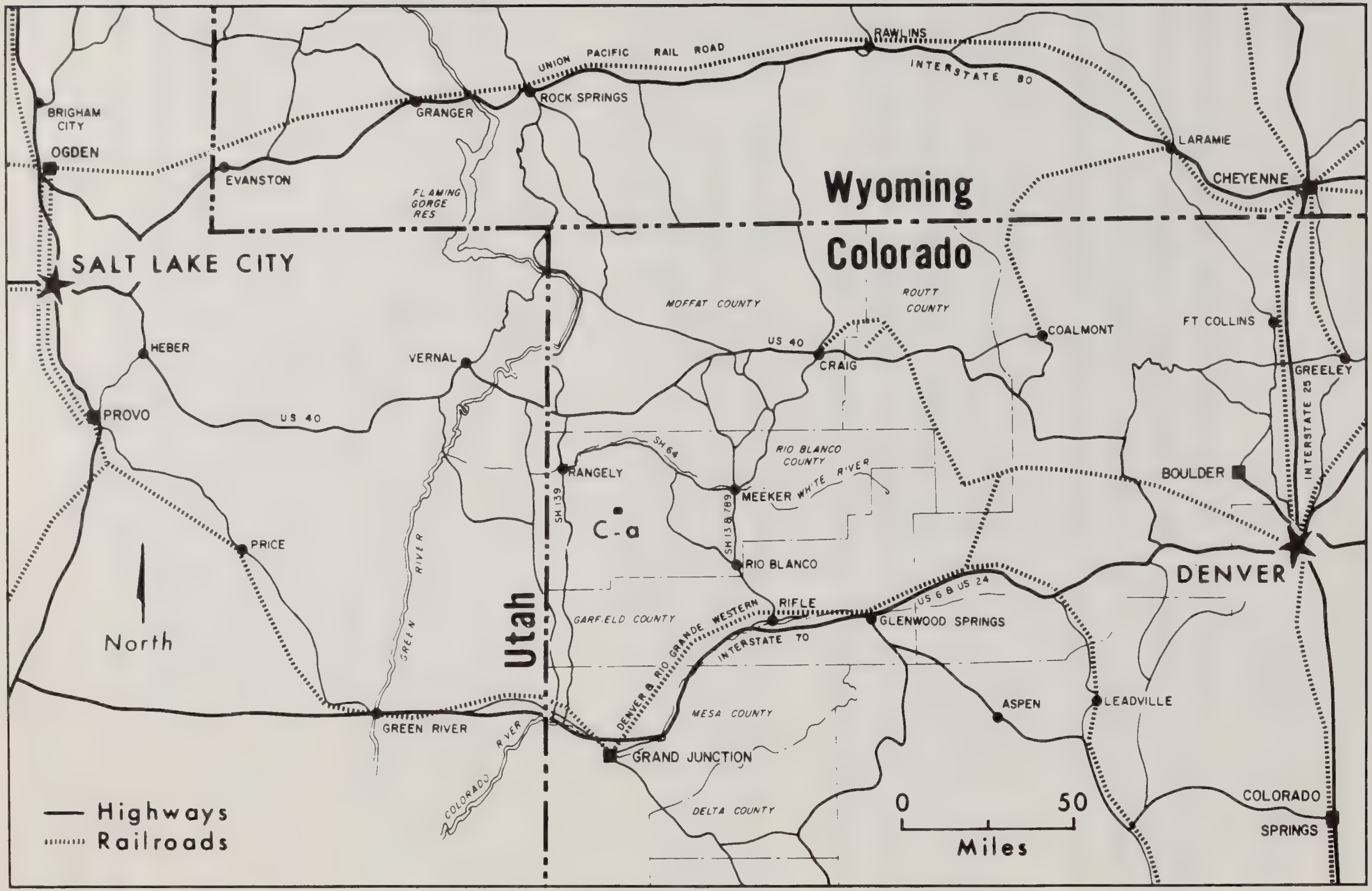



Figure 1-1-1
Regional Map Showing Location of Tract C-a

The lease also contains specific requirements for environmental protection and environmental monitoring.

B. Detailed Development Plan

1. Requirement for Detailed Development Plan - One of the requirements of the Prototype Oil Shale leases is that a Detailed Development Plan (DDP) be filed with the Deputy Conservation Manager - Oil Shale (DCM/OS) before the third anniversary date of the lease. The purpose of the DDP is to outline a program which shows that the lessees will use due diligence for the orderly development of the tract under the terms of the lease.

2. DDP for Open Pit Mining - At the time of the lease sale, Gulf and Standard, as well as the DOI, expected the oil shale on Tract C-a to be mined from an open pit and retorted in surface retorts. The surface processing facilities as well as the initial disposal of the overburden and processed shale would be located off the tract. The entire tract could, therefore, be mined to maximize recovery of the resource. The position of the DOI is expressed in the Environmental Impact Statement (EIS) in several places.

Gulf and Standard submitted a DDP to the DCM/OS in March 1976 which presented plans for producing oil at 50,000 barrels-per-stream-day (BPSD) from shale mined from an open pit. The oil shale would be retorted above ground. The pit was to be started in the northwest corner of the tract and would progress to the southeast. The overburden and processed shale was to be placed off-tract for the first 30 years after which pit backfilling was to begin. The waste material disposed off-tract was to be progressively reclaimed so that the disposal area would be completely rehabilitated soon after backfilling had begun. Similarly, the backfilled portion of the open pit was also to be reclaimed as mining progressed across the tract. Off-tract land required for the operations was approximately the same as the tract area.

3. Suspension - After Gulf and Standard acquired the lease to Tract C-a, the Solicitor of the DOI ruled that the Secretary of the Interior did not have the authority to grant additional Federal leases for surface uses such as disposal and processing facility siting.

In addition, air quality monitoring showed occasional violations of Environmental Protection Agency (EPA) primary and secondary ambient air quality standards for non-methane hydrocarbons, particulates and ozone. Since this was occurring without any industry in the area, RBOSC believed that an oil shale facility could not be built.

As a result of these problems, a two-year lease suspension was requested by RBOSC. A one-year suspension was granted by the government which ran from September 1, 1976 to September 1, 1977.

4. Revised DDP for Modified In Situ Retorting - During the suspension, the EPA reinterpreted their position on the air quality problem so that at least some development was no longer prohibited. Off-tract land for disposal was still not available, however, and RBOSC reevaluated other available technologies. As a result of this examination, a Revised DDP was filed with the Oil Shale Office (OSO) in May 1977. This DDP proposed a plan for developing Tract C-a using the Modified In Situ (MIS) technique combined with surface retorting of the shale mined and brought to the surface in connection with the MIS method. The Revised DDP was approved by the DCM/OS in September, 1977. The plan of action for the approved DDP included surface retorting during commercial operations.

In the MIS process, retorts are created in the shale bed by mining some of the shale from a given volume to develop a void volume to permit retorting. The remaining shale in the volume is rubblized with explosives. Shale oil is retorted by injecting a combustion-supporting gas into the retort volume and retort products (oil, gas and water) are withdrawn to the surface. At the surface the retort products are separated, the oil is processed, the gas is purified to remove sulfur compounds and other contaminants and is used for fuel, and the water is treated and either used internally or discharged. The oil shale mined to create the in situ retorts is retorted on the surface thus producing additional oil.

The Revised DDP presented a 40-year plan for developing the oil shale resource on Tract C-a. The first ten years is a Modular Development Phase (MDP) in which a series of MIS retorts are developed and burned in sequence to gain operating experience, improve process efficiency, confirm capital and operating costs for a commercial operation and ensure environmental integrity of the operations.

Commercial production starts after ten years and runs for thirty years. As planned in the Revised DDP, about 57,000 BPSD of shale oil will be produced by the in situ retorts and 19,000 BPSD will be produced by the surface retorts for a total of 76,000 BPSD.

A Technical Modification to the Revised DDP, which mainly concerned the method of mining underground retorts and the number of retorts scheduled to be burned during the MDP, was approved by the DCM/OS in August 1979.

The configuration for the first three retorts being burned during the MDP is shown in Figure 1-1-2. The void volume for the retorts is approximately 40 percent which will ensure uniform rubblization and even distribution of rubbled shale throughout the retort. Mining for creation of the retorts is required on only one level, G Level. Sub-E Level is required for dewatering.

5. Tract C-a Accomplishments - Retort 0 was developed and burned during the last quarter of 1980, and Retort 1 is currently being developed and will be burned during 1981.

RBOSC has been actively studying the environmental impacts which could result from development of Tract C-a. In 1977, RBOSC completed a two-year baseline environmental program which included studies of meteorology and air quality, terrestrial and aquatic ecology, hydrology, interrelationships among components of the ecosystem, and areas of cultural resources. Since completion of the baseline environmental study, the parameters of the study continued to be monitored.

Further details of the activity on Tract C-a since approval of the Revised DDP in 1977 can be obtained from the Annual Progress Reports for 1978 and 1979. These reports are on file with the DCM/OS.

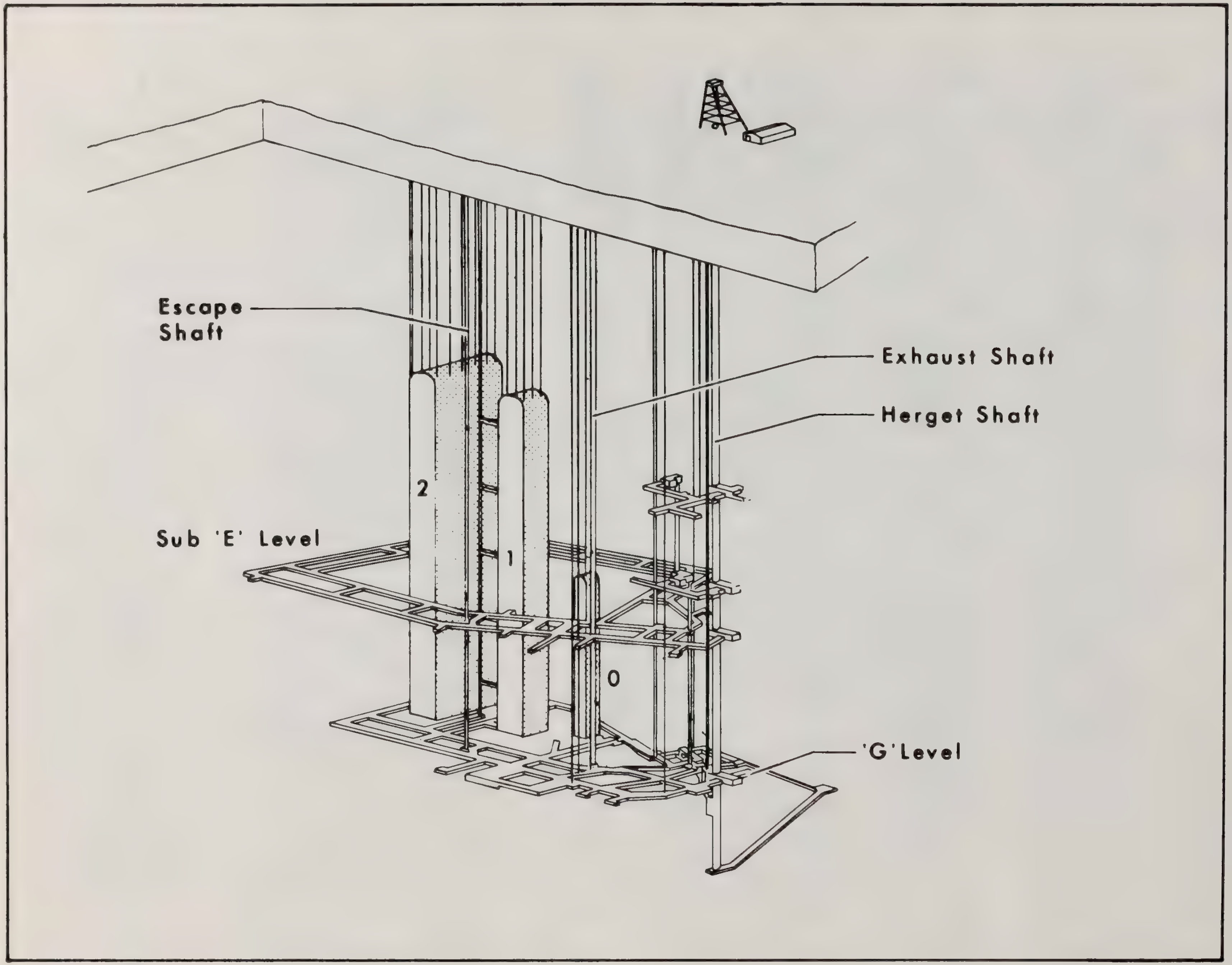



Figure 1-1-2

MDP Mine and Retort Development For MIS Retorts

Figure 1-1-3 is a plot plan of Tract C-a showing the MIS operations area for the MDP.

## 1.2 LURGI DEMONSTRATION PROJECT OVERVIEW

A. Development Objectives - RBOSC is requesting a Modification to the DDP to include the demonstration of a surface retort during the MDP. This modification also includes a small open pit mine to provide feed shale to the surface retort. MIS development may not prove to be the best approach for the commercial development of Tract C-a. Legislation to give the Secretary of the Interior the authority to make off-tract land available failed to pass in Congress in 1980 but is expected to be reintroduced during the 1981 session of Congress. Thus, an open pit mine with a surface retort demonstration unit would be valuable to evaluate. Whether RBOSC proceeds with an MIS or open pit commercial plan, surface retorting of oil shale is required for maximum conservation of the resources.

To obtain technical, environmental and economical information on surface retorting, RBOSC entered into an agreement with Lurgi Kohle Und Mineraloltechnic GmbH for the design of a Lurgi-Ruhrgas surface oil shale retort. The Lurgi plant site and other facilities will be located on an off-tract area adjacent to Tract C-a (Figure 1-1-4). RBOSC agreed with the Colorado Division of Wildlife (DOW) to exchange 457 acres of State land north of and adjacent to Tract C-a for lands of equal value to be designated by the DOW. Prior to completion of the exchange, RBOSC has the full right to use the surface estate in the 457 acre parcel, including all rights for site preparation, construction and all other activities necessary for the Lurgi Demonstration Project. The U.S. Government owns all the minerals underlying the 457 acres with the possible exception of the dawsonite and nahcolite, ownership of which is claimed by the State of Colorado. The 457 acres will be referred to as "the RBOSC off-tract property" in this document. Table 1-1-1 is a legal description of Tract C-a and the RBOSC off-tract property where the operation will occur.

The basic schedule for commercialization has not changed from the Revised DDP. If MIS retorting proves to be successful, commercial scale operations

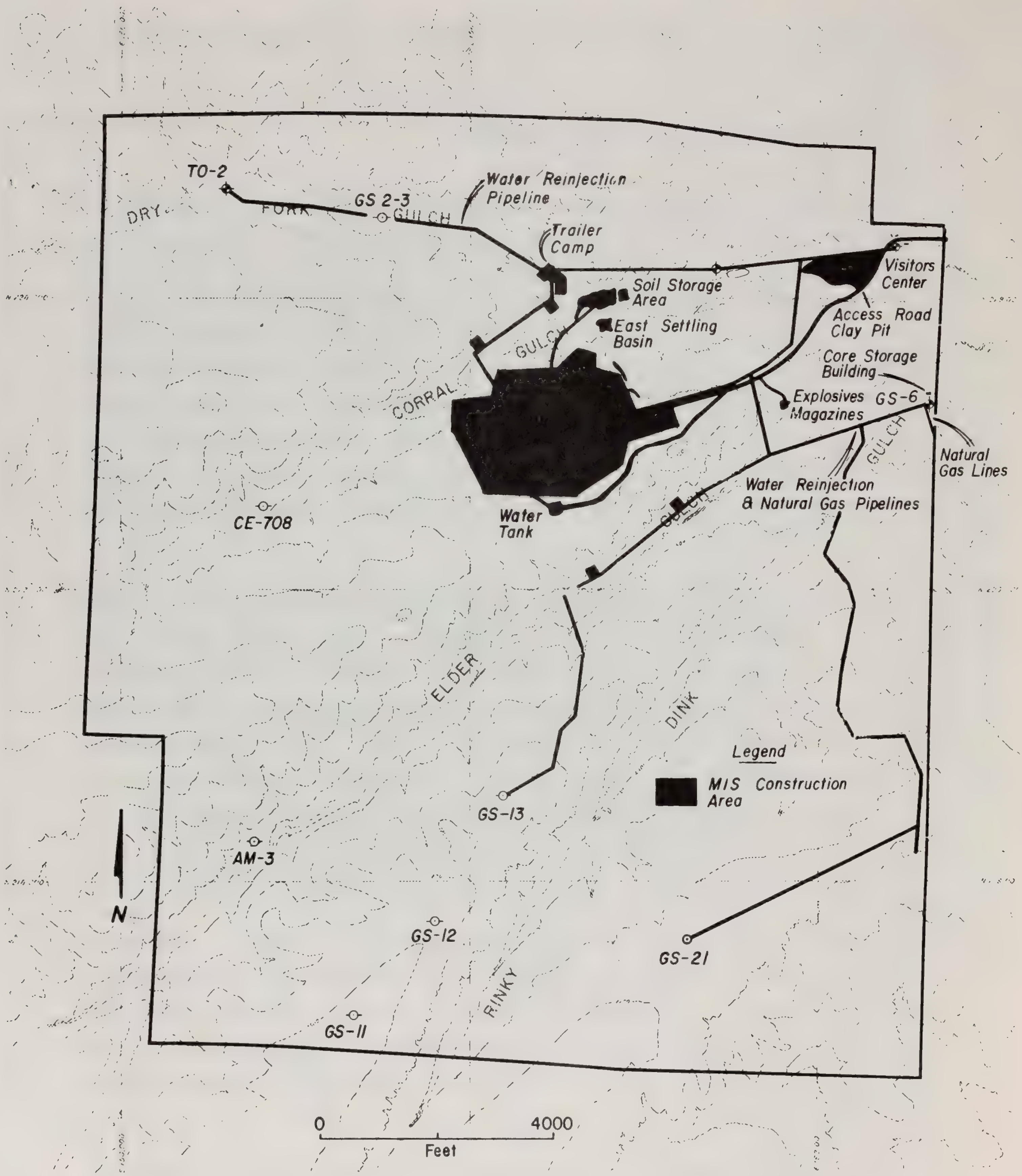



Figure 1-1-3
Tract C-a MIS Plot Plan

TABLE 1-1-1

LEGAL DESCRIPTION OF TRACT C-a AND THE RBOSC OFF-TRACT PROPERTY

TRACT C-A (Lease C-20046)

T. 1 S., R. 99 W., 6th P.M.

Section 32: E½, E½W½
Section 33: All
Section 34: W½, SE¼, W½NE¼, SE¼NE¼

T. 2 S., R. 99 W., 6th P.M.

Section 3: All
Section 4: All
Section 5: E½, E½W½ (including Lots 1, 2 and 3)
Section 8: E½
Section 9: All
Section 10: All

situated in the County of Rio Blanco, State of Colorado containing 5,089.70 acres, more or less, identified as "Tract C-a";

RBOSC OFF-TRACT PROPERTY

T. 1 S., R. 99 W., 6th P.M.

Section 27: NW¼NE¼, S½NE¼, S½NW¼, N½SW¼, SW¼SW¼ and NE¼SE¼

Section 28: S½SE¼

situated in the County of Rio Blanco, State of Colorado containing 457 acres, more or less.

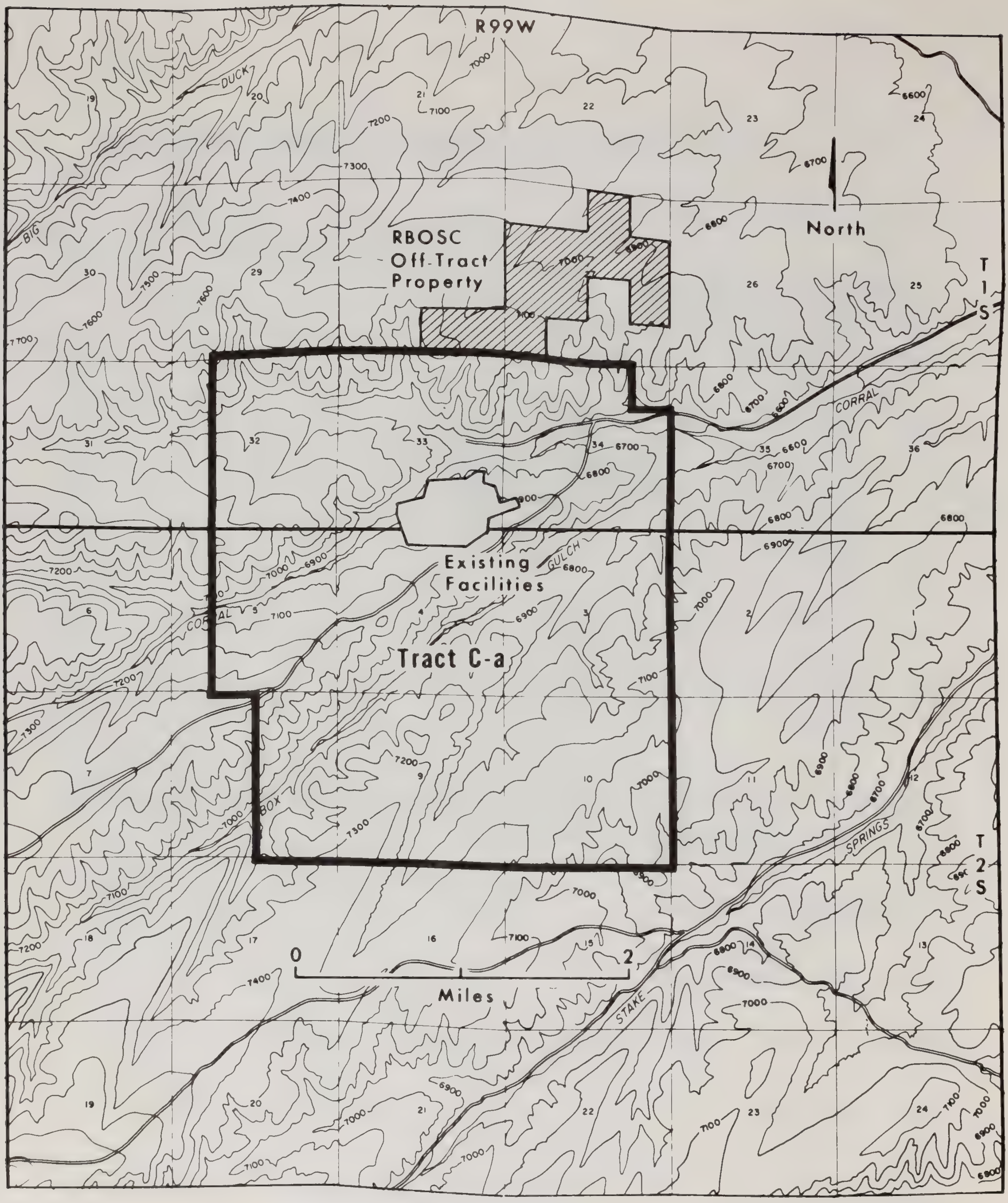



Figure 1-1-4
Lurgi Demonstration Project Off-Tract Site Location

could be reached in 1987. Commercial size is generally regarded as a minimum production of 50,000 BPSD. RBOSC's plan still calls for 76,000 BPSD as shown in the Revised DDP's with 57,000 BPSD coming from MIS operations and 19,000 BPSD from surface retorting. If an open pit mining operation and surface retorting are selected for commercial operations, production of 50,000 BPSD is also possible in 1987. There would eventually be higher production, but such amounts could not be reached until the 1990's and would require expanded facilities.

B. Overall Project Description and Development Schedule - The proposed development plan for the Lurgi Demonstration Project described in this Modification to the DDP consists of a two-year construction period and up to three years of operation of a 4,400 ton per day Lurgi-Ruhrgas surface retort. The plant, support facilities and overburden and processed shale disposal sites will be located on the RBOSC off-tract property. Ore for the Lurgi retort will be obtained from a small open pit in the northwest corner of Tract C-a and the MIS run-of-mine stockpile.

This Lurgi demonstration occurs in two phases: Phase I allows technical, environmental and cost data to be gathered and evaluated to refine commercial planning and Phase II allows operations to continue and be optimized while commercial construction is underway. This modification does not address commercial operations. In addition to the MIS demonstration, RBOSC is currently engaged in engineering design and commercial planning for an open pit mine that would require surface retorting. A decision regarding plans for commercial operations is expected to be made in mid-1982. A plan for these commercial operations will be submitted to the OSO prior to construction. Table 1-1-2 is a summary of information pertinent to RBOSC's proposed Lurgi Demonstration Project. Figure 1-1-5 is a plot plan for the project development and operation. Figure 1-1-6 shows the Lurgi Demonstration Project Construction and Operations Schedule. The information presented above and throughout this document is based on the design to date. As detailed engineering and design proceeds, values and/or locations may change, but the overall concepts presented should remain the same. The following presents a summary of the Lurgi Demonstration Project.

TABLE 1-1-2

LURGI DEMONSTRATION PROJECT SUMMARY

| | PHASE I | PHASE II |
|---|---|---|
| **TIMING** | | |
| Construction | | |
| Process Plant | May 81 - Jan 83 | |
| Mine (Overburden Stripping) | May 81 - Feb 83 | Nov 83 - Feb 85 |
| Operation | | |
| Process Plant | Jan 83 - July 84 | July 84 - Jan 86 |
| Mine (Ore Production) | Feb 83 - Apr 83 | Feb 85 - May 85 |
| **MINING** | | |
| Type | Open Pit | Open Pit |
| Overburden Quantity | 5.2 MM/bcy | 4.2 MM/bcy |
| Overburden Haulage | Truck | Truck |
| Ore Production | 1.2 MM Tons | 1.8 MM Tons |
| Ore Haulage | Truck | Truck |
| Transfer from MIS Stockpile | Up to 0.3 MM Tons | ________ |
| MIS Ore Haulage | Truck | ________ |
| **PROCESSING** | | |
| Retorting | Lurgi 4400 TPD Unit | Lurgi 4400 TPD Unit |
| Processed Shale Quantity (Includes Moisturization) | 1.2 MM Tons | 1.8 MM Tons |
| Processed Shale Haulage | Conveyor Belts | Conveyor Belts |
| Stream Days | 0.5 Factor | 0.75 Factor |
| **PRODUCT SHALE OIL** | | |
| Transportation | Truck | Truck |
| Quantity | 1,000 B/D Avg | 1,500 B/D Avg |
| **AREA DISTURBED** | 559 Acres | 214 Acres |
| **NET GROUND WATER USED** | 350 AFY | 500 AFY |
| **POWER PURCHASED** | 11 MW | 11 MW |

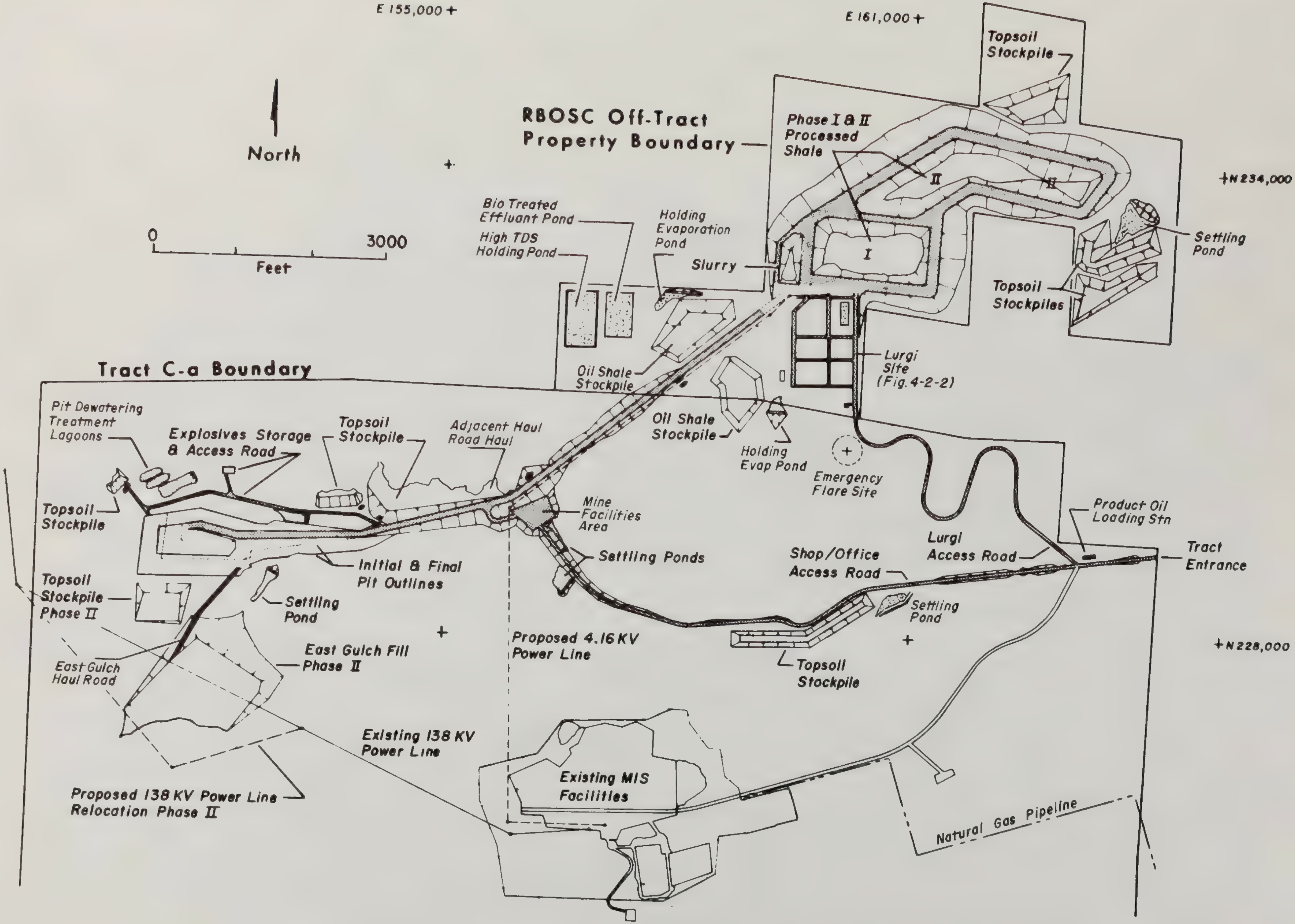



Figure 1.1-5
Lurgi Demonstration Project Plot Plan

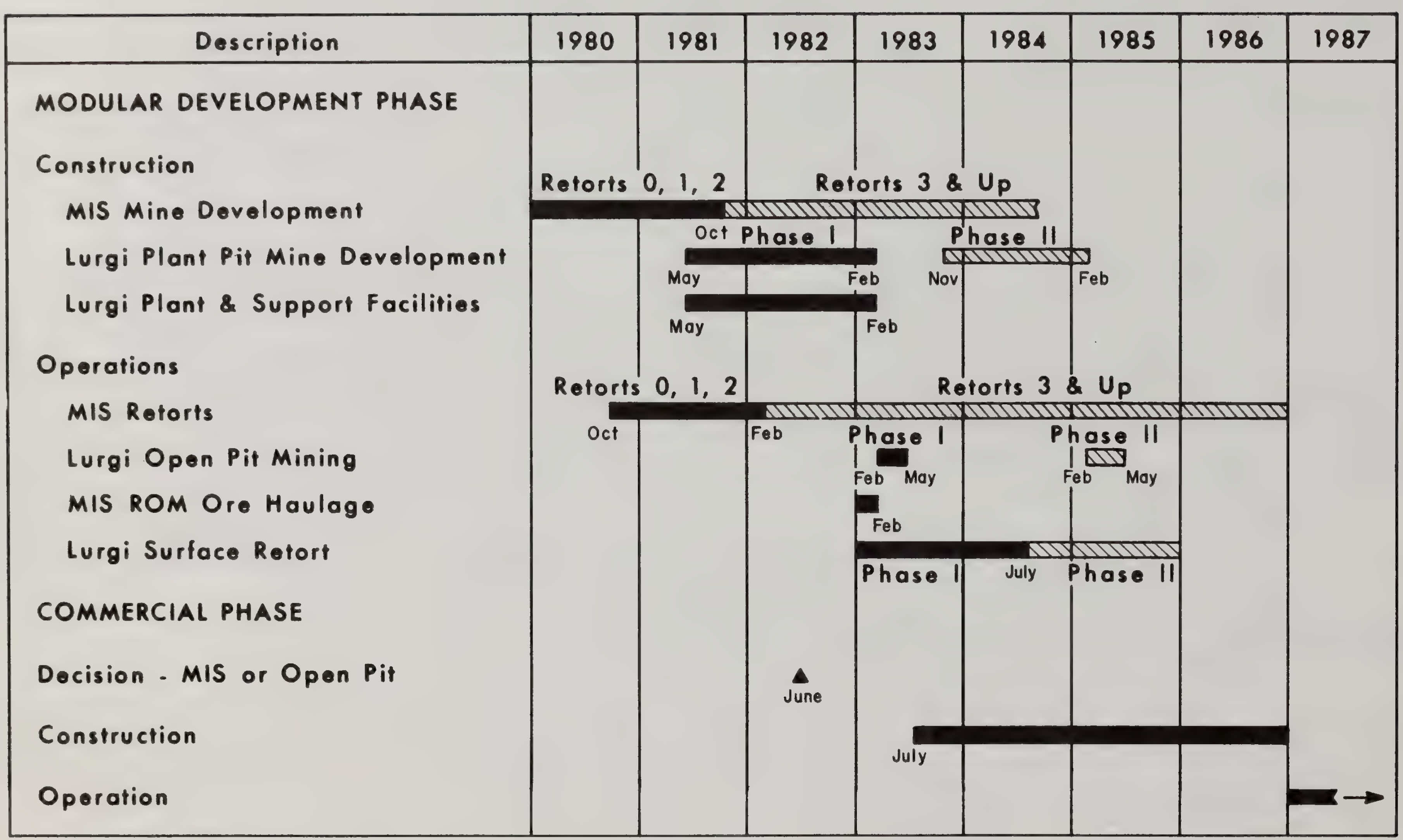



Figure 1-1-6
RBOSC Construction and Operation Schedule

1. Mining - The Lurgi demonstration open pit mine will utilize conventional shovel/truck mining methods to expose and mine 3.0 million tons of oil shale. The open pit mine will be located in the northwest corner of Tract C-a adjacent to the Dry Fork of Corral Gulch.

The open pit development will proceed in two phases. Phase I will be a 20 month operation in which approximately 5.2 million bank cubic yards (bcy) of overburden will be removed to mine 1.2 million tons of oil shale. Phase II will be an 18 month project involving the removal of an additional 4.2 million bcy of overburden to mine an additional 1.8 million tons of oil shale. The Phase II operation will expand the south and west highwalls of the Phase I pit to expose the 1.8 million tons of oil shale. Total pit disturbance for Phases I and II will be 24 acres and 12 acres respectively for a total of 36 acres. Mined oil shale from the Phase I and II pits will primarily come from the Mahogany zone. Although low grade oil shale zones are present above the Mahogany zone, current plans do not include their use. Their quantity and location in the overburden disposal areas will, however, be engineered and located for possible later use. Up to 0.3 million tons of oil shale will be obtained from the existing MIS run-of-mine stockpile.

2. Retort Feed Preparation - Run-of-mine oil shale will be fed from a stockpile to a parallel crushing and screening system which prepares 400 TPH of minus ¼" product for retort feed. One circuit consists of a primary impactor and secondary impactor crusher. The other circuit will be a primary roll crusher and secondary cage mill impactor crusher. Both systems will operate in closed circuit with double-deck vibrating screens. The feed shale will be weighed and conveyed to an enclosed storage building. Automatic reclaiming is provided under the storage pile at the rate of 185 TPH and is sampled and fed to the retort unit by a gravimetric weigh feeder.

3. Processing - Raw shale oil will be produced in a 4,400 ton per day demonstration plant employing the Lurgi-Ruhrgas Oil Shale Process which has been developed by Lurgi Kohle Und Mineraloltechnik GmbH. While the basic process has been successfully applied in the steel, chemical and oil refining industries, this will be its first application to oil shale in the United States.

In this process, properly sized raw shale will be delivered to a feed bin at the top of the process tower. From the feed bin the feed shale is delivered to the Lurgi mixer where it is mixed with hot, recycled, processed shale and is heated to a temperature of 900 to 1,000°F. At this temperature hydrocarbon vapors are released from the oil shale. The products of the retorting process are then passed through an oil condensation area consisting of three condensation/scrubber towers which recover the raw shale oil in three different fractions - heavy, medium and light oils. The heavy oil fraction contains fine particles of processed shale which are removed in the heavy oil dedusting area. The oil products are ultimately delivered to product storage tanks from which they are transported by tank trucks for delivery to markets.

The mixture of hot solids falls from the Lurgi mixer to a surge bin from which it enters the lift pipe. There it is contacted by a hot air stream of about 840°F to initiate combustion of coke and is lifted to the collecting bin. Residual carbon on the "fresh" processed shale will be burned as the material is lifted, along with auxiliary fuel as necessary, to achieve a temperature of approximately 1,200°F.

As the hot processed shale stream reaches the collecting bin, a measured portion falls to the bottom of the collecting bin, completing the Lurgi loop while the remainder continues out of the collecting bin with flue gas to heat air and generate steam.

In the heat recovery area, the flue gas/processed shale mixture flows through an air preheater and a steam generator. The cooled mixture will pass through cyclones and an electrostatic precipitator for the removal of particulates prior to emission of the flue gas to the atmosphere through the stack.

The processed shale, which has been collected in several locations, is delivered to a processed shale cooler and then to a moisturizer. From there it goes to a conveying system for transport to the disposal area.

Part of the product gas which exits the condensation area is used as fuel in the lift pipe. The remainder is incinerated, then treated by an $SO_2$ scrubber prior to discharge to the atmosphere by a stack 310 feet above ground level.

4. Processed Shale and Overburden Disposal - The processed shale and overburden disposal system is designed to demonstrate disposal techniques and to collect pertinent data which will be used to optimize the design and operation for the processed shale disposal system for a commercial operation. The disposal plan for Phase I is based on mining and retorting production schedules. Mining and disposal of overburden is scheduled to begin September, 1981. Disposal of processed shale is scheduled to begin when the demonstration retort is operational and oil shale is fed to the retort. A total of 1.2 million tons of processed shale will be produced in this phase.

Results of laboratory tests of the physical and chemical characteristics of the processed shale and overburden were considered in the design of disposal piles. The processed shale will be a very fine-grained material while overburden being run-of-mine material will be coarse. To demonstrate the physical and chemical stability, permeability and resistance of the processed shale to leaching by water, all processed shale for the demonstration phase will be contained in dikes. All Phase I overburden not needed for road or facilities construction will be used to build the dikes necessary to contain all Phase I processed shale. Topsoil stripped during construction will be stockpiled and used for reclamation. There will be more than enough overburden available for this purpose, and the excess will be used to start the Phase II containment dike. The overburden includes zones of low grade oil shale that is not considered economically recoverable at this time. Side slopes of 3:1 will be used on containment dikes. Finer overburden material will be placed to the inside of the dikes and coarser material to the outside. Before disposing of any processed shale, an impervious liner will be placed inside the Phase I dike to allow surface runoff and leachate to be collected for analysis. Several test plots will be set up to analyze various environmental and mining operational properties of the processed shale such as materials handling, stability of waste, leachate quality, reclamation, erosion and dust control. After the 1.2 million tons of processed shale has been placed in the disposal area and testing completed the disposal will be reclaimed. Containment dikes will be revegetated as soon as they are in place. If 3:1 slopes are too steep for effective revegetation, 4:1 slopes will be made by decreasing the width of the top of the containment dike. The processed shale will also be covered with a layer of overburden, topsoiled and revegetated.

The Phase II disposal system will be designed using the results of the Phase I program. Phase II will mine an additional 1.8 million tons of oil shale in the same manner as Phase I. The overburden removed to mine the oil shale will complete the Phase II containment dikes; the remainder will be stored in a gulch area immediately to the southeast of the pit. The overburden stored adjacent to the pit and the spoil used as fill on the haul road and facilities area will be used to backfill the final pit if the site is abandoned. The processed shale from the Phase II operations will be placed by conveyor within the Phase II containment area. After completion of Phase II oil shale processing and testing, the Phase II containment area dike will be completely reclaimed.

5. Support Facilities - A wide range of support facilities will be required for the Lurgi Demonstration Project. The most significant of these will be: Transportation systems - equipment and materials will be shipped to the project vicinity by rail and the site by truck; Electrical Power Supply - the demand for electrical power will be approximately 11 MW which will be supplied from an existing 138/240KV transmission line to Tract C-a which is tied to the Moon Lake Electric Association system. A new 138/23KV substation will be installed near the existing main substation at the MIS facility; Product Storage and Transportation - the raw shale oil will be stored in two product storage tanks of 45,000 barrels capacity each. The produced oil will be piped to a truck loading station near the tract entrance; Communications - Mountain Bell Company will provide telephone service from Meeker with sufficient capacity to accomodate intra-project, local and long distance calls. Radio/telephone facilities will satisfy communications during the early phases of construction; Fuel and Other Service Products - Diesel fuel, gasoline, lubricating oil, hydraulic fluid and anti-freeze will be distributed in accordance with recommended procedures and stored in appropriate containers for both construction and long term operating requirements; Buildings - buildings required for the mine area and the process area will be designed for the service required. Major buildings to house personnel will most likely be of structural steel with precast concrete panels; Explosive Storage and Handling - Explosives and blasting agents required for mining and construction will be provided in accordance with applicable State and Federal regulations.

6. Environmental Protection, Health and Safety

a. Water Management and Quality Control - Water for the Lurgi Demonstration Project will be obtained from Upper Aquifer ground water. This water will be extracted by water supply wells or mine sumps and transported by pipelines to the mine facilities, the Lurgi plant area and the processed shale disposal areas where principal project water uses are centered.

Emphasis in the water management plan is placed upon reuse of waste water streams in order to conserve area water resources. Under normal operating conditions, the only waste water stream which will not be reused is a sanitary effluent stream from the mine facilities area. This sewage, which represents a flow of only 8,000 gallons per day, will be treated and discharged. All other waste streams will be reused within the system, although NPDES discharge permits will be obtained for waters at various points in the system in order to maintain flexibility in the water management program.

Inflows into the mine are expected to exceed water demands over most of the life of the project. The pit seepage will be pumped to holding and settling ponds for clarification, and then into the system water supply. Most of the excess water in excess of consumptive use requirements will be returned to the ground water system by means of injection wells. On rare occasions, excess water may be discharged to Dry Fork. Thus, under normal operating conditions, only that amount of water required for the plant and mine operation will be removed permanently from the ground water system although an NPDES permit will be obtained for discharge of excess water to Dry Fork to maintain operating flexibility.

Control of surface waters is to be achieved by three methods. Surface water runoff from undisturbed areas will be diverted away from the facility areas by ditches or culverts so that these waters are segregated from runoff from disturbed areas. Runoff from disturbed areas will be directed to settling basins where suspended solids will be removed. NPDES permits will be obtained for each of these basins, and the collected storm water will be discharged from the basins when the permit standards are achieved. When water is in storage in the ponds, it may be used as an auxiliary source of water for dust control. Runoff from the ore stockpiles and the unreclaimed processed shale disposal area will be directed to holding ponds. If the quality of this water is not adequate for utilization in project operations, it will be evaporated.

The volume of the settling ponds is sufficient to contain the runoff from a 10-year, 24-hour storm plus a three-year accumulation of sediment. The ponds will be cleaned to maintain these storage volumes. The volumes of the holding ponds were selected as the maximum of the runoff from the 100-year, 24-hour storm, and the maximum accumulated volume predicted to have a one percent chance of occuring.

The Lurgi processing facility itself will generate two waste streams. One stream is made up of the retort water, effluent from the sewage treatment plant, and rain water collected from areas, such as the processing and product storage areas, where it may have become contaminated. This waste stream will be treated by means of a facultative lagoon, a sand filter and activated carbon filters. An NPDES permit will be obtained for this tertiary treated waste stream to allow for operational flexibility; however, under normal conditions the treated water will be returned to the process system where it will be evaporated in a cooling process. The second stream is composed of high TDS water from brines and treatment facility blowdowns. This stream will be utilized for moisturizing a portion of the processed shale, and will not be discharged. Sufficient in-line storage for both streams will be provided to allow several months of plant and treatment system testing without discharge or final disposition of the streams.

b. Air Quality Control - RBOSC recognizes that preservation of the air quality of the Piceance Basin is of utmost importance. Thus, every reasonable effort will be made to control fugitive dust, to minimize particulate and gaseous emissions, and to maintain air pollutants at levels below the State and Federal standards. The best available control technology will be used. Soil stabilizers, dust retardants, dry-fabric collection devices, high-efficiency electrostatic precipitators and other state-of-the-art control devices will be employed to maintain the air quality of the Tract C-a area.

RBOSC has conducted detailed modeling to assess the combined impacts of the proposed project and other regional sources on local and regional air quality.

Other sources included in the modeling are the Cathedral Bluffs MIS retort and underground mine (5,000 bbl/day), Colony Development Corporation's proposed 46,000 bbl/day surface retort and underground mine, and the Union Oil Company's proposed 9,000 bbl/day surface retort and underground mine.

The Multiple Point Source Diffusion Model (MPSDM) including complex terrain flow assumptions was used to model the concentration of $SO_2$ and TSP in the Piceance Basin and surrounding areas. The MINE model, incorporating the Ermak deposition function, was used to predict maximum TSP concentrations due to fugitive dust generated by project-related activities.

The modeling results indicate that local and regional air quality will comply with the Federal and State Ambient Air Quality Standards and that Class I and Class II increments for $SO_2$ and TSP will not be exceeded.

c. Other - The land rehabilitation objectives are to reclaim disturbed areas by returning them to a state consistent with pre-existing land uses in the area and compatible with existing adjacent undisturbed natural areas. The principal elements considered are site preparation, erosion control and revegetation for project development areas such as the open pit mine, haul road, plant site, parking lots, conveyor corridors, access roads, transmission line, etc.

An abandonment plan has been developed to meet the terms of the Tract C-a lease and guidelines of the regulatory agencies. The primary objective of the abandonment plan is to return the site to a relatively stable physical condition which is compatible with the surrounding ecosystem. Removing obvious signs of man's intrusion and establishing a self-sustaining vegetative cover will be the major objective of the process.

The Fish and Wildlife Management Plan is designed to avoid, minimize, and/or mitigate damage to fish and wildlife habitat as required by the DOI in its lease stipulations. The plan consists of four parts: wildlife habitat enhancement, wildlife habitat restoration, human disturbance control and a habitat modification monitoring program. The habitat enhancement program will offset loss-of-habitat impacts by increasing the carrying capacity of non-impacted wildlife habitats through habitat modification and an increase in water availability. Habitat restoration will involve recontouring, replacing topsoil and revegetating disturbed areas. Potential adverse impacts from human disturbance (e.g., increased roadkill, hunting pressure) will be mitigated by RBOSC through a combination of education efforts and employee regulations. Vegetation productivity changes and vegetation utilization by mule deer will be monitored to determine the level of success of the habitat modification program.

A plan for control of oil and hazardous material and wastes has been formulated recognizing that the best control plan is to prevent spills through proper design of storage, handling and transporting facilities, and by designing process equipment to eliminate or reduce accumulation of hazardous wastes. The Spill Contingency and Hazardous Waste Management Plan is being developed to ensure safe storage, handling and disposal of oil and hazardous materials and wastes and to ensure the proper containment and cleanup of spills of these materials. The detailed plan, kept on site for use by tract personnel, includes procedures for the following: sampling and analysis of waste streams and discarded materials; proper storage, treatment and disposal of oil and hazardous materials and wastes; contingency actions to be taken in case of accidental spills or discharges of oil or hazardous materials or wastes; notifications; record keeping; training; inspections; monitoring; and proper closure of oil or hazardous materials or wastes storage areas.

In addition, RBOSC has conducted an on-site inventory of all MIS and Lurgi Demonstration Project-related petroleum product storage facilities and potential spill points, all process waste streams and discarded materials. Information from this inventory will be incorporated into the Spill Contingency and Hazardous Waste Management Plan.

A solid waste control plan will be developed to assure properly controlled disposal of solid wastes, excluding processed shale and overburden. Solid wastes will include process and non-process (paper, wood, metal) and related wastes.

The demonstration plant will be designed, constructed and operated with a major objective of providing a safe work place for both workers and the public. A health and safety program will be implemented during construction in recognition of the specific hazards of construction operations. An ongoing health and safety program will be implemented upon commissioning of the plant. This will include areas of special concerns such as toxicology studies, noise control, protection to the public, fire protection programs, etc. This program will receive continuing senior management support and supervision.

As determined by the BLM from review of the Cultural Resources Survey Report for Tract C-a and vicinity two sites in the survey area may be eligible for the National Register of Historic Places. Therefore, RBOSC proposes a program to protect these and any other significant cultural resources. The program includes: 1) preventing inadvertent damage to significant cultural resource sites by pre-planning activities to avoid sites recommended for protection until testing and salvage of the site is completed by a qualified archeologist and 2) providing equipment operators with enough information to recognize the presence of historic and scientific resource material, particularly that which is in the subsurface, so that appropriate action can be taken. In addition, employees will be prohibited from collection of artifacts as per law and will be asked to report all finds to RBOSC management. As these measures are expected to provide ample protection for significant cultural resources in the study area, projected adverse impacts on cultural resources from the project are expected to be zero. The existing Determination of No Effect issued by the BLM was deemed by the State Historic Preservation Offices on November 17, 1980, to be applicable to the Lurgi Demonstration Project.

7. <u>Environmental Assessment</u> - The basic tool employed in identifying, assessing, mitigating and monitoring environmental impacts associated with RBOSC's ongoing MIS project was a cause-and-effect matrix. This matrix was used to identify potential impact sources, identify environmental variables likely to be impacted and assign ratings reflecting the importance and anticipated severity of environmental impacts. Following this initial assessment, mitigation measures were proposed for significant impacts, and net impacts were assessed based on the anticipated results of such mitigation.

Impacts which could be efficiently monitored were identified, and a monitoring program was designed.

The cause-and-effect impact assessment matrix developed for the MIS project was not reproduced during the Lurgi impact assessment, but rather the outputs of the MIS matrix were modified to reflect differences between the two projects. The result was an assessment of the probable environmental impacts, without mitigation measures, of the proposed Lurgi Demonstration Project. Mitigation measures were developed to reduce these impacts, again relying heavily on experiences with MIS. Based on these mitigation measures, the probable net impacts of the Lurgi Demonstration Project were assessed. These net impacts are briefly summarized below.

Air quality dispersion modeling results show that no National Ambient Air Quality Standards (NAAQS) or Colorado ambient standards will be exceeded due to air quality impacts from the Lurgi Demonstration Project. Likewise, no applicable Prevention of Significant Deterioration (PSD) increments will be exceeded, nor will there be adverse visibility impacts either in the vicinity of the tract or at the nearest Federal Class I area, the Flat Tops Wilderness Area.

Impacts to the terrestrial ecology of Tract C-a and vicinity from project development will result from the following sources: construction, mining, operations, storage and transfer, disposal and secondary (manpower-related) activities. Several of these activities will involve destruction of terrestrial habitat; necessary fencing of operations areas will cause other habitat to be functionally destroyed, as the carrying capacity of such areas will be lost for the duration of the project. Vegetative productivity of habitats adjacent to developed areas may be decreased somewhat due to fugitive dust emissions associated with project activities. In addition, the noise levels produced by project-related activities may adversely impact the breeding success of terrestrial species and diminish animal numbers in the immediate vicinity of activity. Species which are expected to be most affected by these impacts include mule deer, avifauna, small mammals, feral horses and domestic livestock.

Only minor impacts to the aquatic communities are expected from project development. Construction activities may cause aquatic community changes due to habitat alterations or increased sedimentation; however, these impacts will be limited to communities on or near the tract. Mine dewatering will decrease some stream flows. These decreases in flow will result in impacts on periphyton and benthic communities in such areas. Additional impacts which may occur from periodic discharges into Corral Gulch include erosion of streambanks and scouring of the stream bottom near the points of discharge. No adverse effects to aquatic organisms from leachate are expected, as RBOSC is designing a processed shale disposal facility that will contain all leachate from the processed shale.

Major hydrology impacts could result from water consumption, an expanded cone of depression, sediment laden discharges and spills or leaks of contaminated water or products. The water management plan emphasizes recycling of water to minimize consumptive use. Excess mine seepage will be reinjected into the existing reinjection well system to contain the cone of depression to the south and east of the pit. Numerous detention ponds will be constructed to remove sediment from surface runoff. Containment structures will gather spills in the plant area and convey them to the waste water treatment facilities.

Only two tertiary (minor) sites identified by a 100 percent survey of the cultural resources of Tract C-a and vicinity will be directly affected by the Lurgi Demonstration Project. The BLM prepared a Determination of Effect (with concurrence from the State Historic Preservation Officer) which concluded that no adverse impacts to significant cultural resources will result if proper mitigation procedures are followed. Based on the results of the survey and determinations issued by the BLM and the State Historic Preservation Office, no adverse impacts to significant cultural resources are anticipated as a result of the project.

8. Environmental Monitoring - The RBOSC Environmental Monitoring Program for the Lurgi Demonstration Project is designed to: 1) fulfill the monitoring stipulations of the Tract C-a Oil Shale Lease, 2) fulfill the monitoring requirements of Federal, State and local permits and 3) evaluate the success

of RBOSC environmental protection programs (impact mitigation measures) by assessing the net impacts of the Lurgi Demonstration Project.

Development of the environmental monitoring program involved determining the potential impacts of the project and selecting methods to monitor these impacts. Impacts which were assessed as significant, measurable, and having dependable indicator parameters were selected for monitoring. Also included were impacts which are sensitive from a public or regulatory standpoint, and any specific monitoring requirements of the OSO. The selected impacts are believed to reflect environmental conditions on Tract C-a and the adjoining project area. Monitoring methods were selected by RBOSC environmental specialists based on their personal experience, on data collected during the baseline studies and on knowledge of the type and format of data required by various agencies.

Monitoring and/or evaluation programs were developed for air quality, meteorology, terrestrial ecology, aquatic ecology, hydrology, and special studies. In addition to these programs, specialized studies are conducted on an as-needed basis. A scope of work (RBOSC MDP Environmental Monitoring Program, Revision 6.0, RBOSC 1980) was developed for each of the programs and submitted to the OSO. These scopes supply detailed information on specific monitoring objectives and development of techniques designed to accomplish these objectives.

RBOSC has established quality assurance, data management and reporting procedures as part of the environmental monitoring program. The RBOSC Quality Assurance Program is designed to provide documentation that the environmental monitoring program is being conducted in accordance with the approved scope of work and in compliance with standard, approved scientific methods and procedures. The RBOSC Data Management System is an integrated process designed to enable rapid and relatively easy access and retrieval of data collected in the RBOSC Environmental Monitoring Programs. The data management system also functions as a quality assurance component, as data are reviewed and verified several times during the process. Mid-year and year-end data reports are submitted at the end of August and March, respectively, of each monitoring program year. Mid-year reports contain reduced and raw data collected during the specified reporting period and short, narrative descriptions of results. Year-end reports contain raw and reduced data for the previous reporting period; yearly summaries, analyses and interpretations of the 12-month data set; and, where appropriate, comparisons between years, seasons and other data sets (e.g., DOW data). The year-end report is designed to continually update the data base for the tract. Trends are identified, anomalies are flagged and long term evaluations are made. Development-linked perturbations are identified and assessed as to significance. Possible mitigation procedures are recommended.

9. Construction Activities - Construction activities will be coordinated to minimize land disturbance and to avoid unnecessary disturbance. Vehicular traffic will be restricted to established roads, where possible.

Major areas of construction activities are the mine office and shops, haul road between the open pit mine and processing area and the surface retort processing and support facilities, as described below.

a. Mining and Related Areas - Construction will include the following:

- Clearing and grubbing
- Salvaging top soil and storage in stockpiles
- Removal and storage of overburden and preparation of haul road
- Access road construction to process area and mine shop/office area
- Preparation of processed shale disposal areas and construction of dikes and holding basins
- Excavation of mine to supply feed shale to retort process area

Construction sequence of mining and related areas is, in general, as follows:

- Mobilization and move-in to commence the access roads to the Shop/Office area where the construction facilities will be located

- Development of the temporary facilities to support the mining operation
- Removal of top soil from the disturbed areas and storage in designated areas
- Removal of overburden from the open pit mine area and use of this material as fill for the haul road, mine facilities and process area and for constructing the processed shale disposal area
- Removal of the overburden for Phase I operations will continue until approximately the beginning of 1983 when the stockpiling of feed shale will start. The feed shale stockpile will be located near the crusher building of the surface retort demonstration plant
- Construction activities will phase out in early 1983 but the hauling operation between the mine and the process area will continue as necessary to provide sufficient oil shale for the operation of the processing unit

b. Processing and Support Facilities - Construction will include the following:

- Clearing and grubbing
- Salvaging top soil and storing in stockpiles
- Site preparation and construction of plant access roads
- Constructing facilities to prepare shale for retorting, including facilities for crushing and grinding and transporting
- Constructing Lurgi processing facility
- Constructing offsite facilities, including steam, water and fuel supply systems
- Constructing waste water treatment, product off-gas disposal and product storage and transfer systems
- Constructing administrative support facilities such as offices, warehouses, machine shops, fire, safety and communications systems

Construction sequence for the processing and support facilities is, in general, as follows:

- Mobilization and move-in to commence site preparation will begin in May of 1981. Temporary facilities, (water, communications, power, concrete batch plant, etc.) will be developed to support the construction program. During site preparation, excavation and foundation work will also start for the administration/warehouse and the feed shale storage building with the erection of the buildings to proceed immediately thereafter.
- Excavation will be started for the underground firewater system, drainage system and the underground electrical duct work that will carry permanent power to the plant
- During the winter period of 1981/1982, the feed shale storage building will be utilized as a piping fabrication shop in order to be ready to erect piping during the good weather months of 1982
- Erection of structural steel for the retort process area, crusher building, pipe ways etc. as the foundations are completed
- Grading, earthwork and construction of containment dikes will proceed as practical without conflicting with the mechanical erection of major structures
- Proceeding with construction of boilers, water treating and waste treatment, product gas incinerator and $SO_2$ scrubber, and storage tanks as areas are prepared and foundations are completed
- During the erection of structural steel for the retort area, process equipment will be erected in its proper place. The three major process systems within the retort area are distillation, condensation, and waste heat recovery and shale cooling.
- The process equipment that will be erected within the retort area includes: bins, mixers, cyclones, preheaters, humidifiers, electrostatic precipitator, steam generator, drums, blowers, scrubbers, coolers, tanks, pumps, etc. This equipment will be interconnected with piping, electrical, and instrumentation work after the equipment is erected.

Other minor buildings will be erected at the Lurgi plant site to house the control room and electrical substation.

Fencing portions of the Lurgi Demonstration Project area will be done to protect the public from hazards and to keep livestock and feral horses out of certain areas such as holding and evaporation ponds and the processed shale pile. Other specific areas to be fenced will be identified as the project progresses.

During the final months of construction, following hydrostatic testing of systems, insulation of equipment and piping and painting will be taking place.

Construction activities of the retort, administrative and utility areas will start phasing out in the fall of 1982. Erection equipment will be removed from the site. A general clean-up of the entire area will be performed and as construction activities diminish, the operation of the plant by permanent employees will start.

C. Projected Costs - After Gulf and Standard leased Federal Prototype Oil Shale Tract C-a for $210 million, $126 million was paid in cash to the Federal government. RBOSC is currently involved in demonstrating the feasibility of the MIS technology. This demonstration program is completely funded by Gulf and Standard at an estimated cost of $140 million. The Lurgi Demonstration Program consists of three phases - design, construction and operation. The total cost of this program, which will take four to five years, is estimated to be approximately $160 million. This is in addition to the above mentioned costs. At this time, all of these funds will be supplied by Gulf and Standard.

## 1.3 SOCIOECONOMICS

A. Background - Shortly after acquisition of the Tract C-a lease in 1974, RBOSC began a series of efforts to enhance planning for growth in northwestern Colorado. In 1974, $40,000 was contributed to Rio Blanco County to assist in the preparation of a County Master Plan which was subsequently completed and adopted. Another $86,000 was spent with Foundation for Urban and Neighborhood Development (FUND) of Denver to make a socioeconomic study of the communities of Meeker, Rangely and Rifle. That study indicated that

Rangely was especially supportive of growth and would be a community C-a workers would choose if the commuting distance could be reduced by extension of County Road 24 from the tract to Rangely.

Also in 1975, Morrison-Knudsen, RBOSC's general contractor, completed a $60,000 economic baseline study of the town of Rangely. Included were a housing survey, breakdown of the current work force by occupation, age and sex; and similar data. In addition, RBOSC paid $88,000 to the County for upgrading work and bridge improvement on existing County Road 24 between the Piceance Creek Road and Tract C-a. That road was later further improved and paved by Rio Blanco County with money from the Oil Shale Trust Fund. (The Trust Fund was created by the Colorado Legislature to reserve the State's share of the lease bonus money for mitigating oil shale impacts on the affected communities in the oil shale region.)

In 1976, RBOSC employed International Engineering, Inc., a subsidiary of Morrison-Knudsen, to design an extension of County Road 24 which would meet State highway standards. Twenty miles of new construction would provide a 25-mile route from Tract C-a to Rangely. Design cost was $312,000.

In the same year, Rio Blanco employed the Gulf Oil Real Estate Development Company (GOREDCO) to assist Rangely in developing a comprehensive plan for the town's growth. That plan was completed, adopted by the town, and approved by the County. The total cost of that project was approximately $245,000.

In 1977, to assist Rangely in its efforts to obtain additional Federal land for town expansion, RBOSC provided $6,000 in legal assistance for preparation of an application to the BLM. That legal assistance was also used to review and codify the town ordinances and codes.

B. Tract Activity - Following completion of the suspension of operations between September 1, 1976 to September 1, 1977, site preparation for the MIS demonstration began. By early 1978, there were approximately 100 contractor employees on tract. The number reached 234 by early 1979.

Although Rio Blanco County and the Colorado West Council of Governments sought funding from the Oil Shale Trust Fund every year, the Colorado General Assembly was reluctant to authorize expenditures to construct the new section of road to connect Tract C-a with Rangely. There were always questions about whether or not Tract C-a would be commercially developed. The latest cost estimate to build the road was $15 million in 1977.

In 1978, an alternative route was recommended by Rio Blanco County. The new proposed route, while about 10 miles longer, was also about half as costly. This route was presented to the General Assembly for funding. An amount of $300,000 was approved for engineering in 1979. In 1980, just over $2 million was authorized but was noted as the last expenditure for the Rangely to C-a road. To date efforts by the county to obtain necessary rights-of-way have been unsuccessful so the road issue remains unresolved.

With no new road, Tract C-a employees have migrated primarily to Rifle and Meeker the past two years. Rifle is about 58 miles from Tract C-a, Meeker is 51 and Rangely is 68 miles away.

Peak work force to date at Tract C-a has been 485 reached in September 1980. With completion of the major mining effort, the work force dropped to 384 in early December 1980. Of that number, 321 were living in the Rifle area, 50 were in Meeker and 13 were in Rangely.

As the work force increased in 1978 and 1979, RBOSC and its contractors began to provide group transportation in the form of vans and carpools. By the Fall of 1979, about 90% of Tract C-a workers were being transported in some form of group transportation.

In March 1980, a sufficient number of employees were located in Rifle to justify bus transportation. Two buses were leased on a two-month trial basis. Because the test was so successful, two more buses were acquired and put into service by September 1980. By December 1980, three buses were operating between Rifle and Tract C-a and one bus was being used for Meeker. The four buses run at between 81 and 100% capacity. Vans make up the great majority of the balance of transportation needs where shifts are small or numbers do not justify a bus. Vans run at about 83% of capacity.

In housing, Rio Blanco is guaranteeing rental on 25 units of a mobile home park in Rangely which opened for occupancy in 1980. As of December, about 20 of these spaces are occupied.

C. Future - Reduction of underground miners balanced against an increase of workers connected with the Lurgi Demonstration Project construction is expected to result in work force numbers totaling less than 550 through 1984.

Figure 1-1-7 shows RBOSC's estimated employment projection through 1984. The manpower shown through about February, 1982 includes Lurgi plus MIS personnel; after that time, only Lurgi manpower is projected.

Transportation for the foreseeable future will continue to be by bus supported by vans and carpools.

RBOSC is committed to the development of a housing plan by the completion of the three MIS demonstration burns (scheduled to be completed in early 1982). The agreement was made with Rio Blanco County.

As a major part of that effort, RBOSC has engaged Holleran Services, Inc. to assist in the development of a long range plan to deal with housing and other social and economic impacts which could be caused by the Tract C-a project. Holleran's scope includes planning for construction and operation of a bachelor housing facility, possibly on-tract, to house construction people. Such a camp would have the following advantages for this segment of the work force when the Lurgi retort is built:

- House short-term construction workers whose employment duration would not justify buying a home or moving a family into the area
- Provide initial short-term housing for longer-term employees while they are seeking housing in one of the existing communities, or while they are waiting for a house to be built
- Provide facilities for supervisors, key employees, and others involved in plant upsets, emergencies, or special circumstances requiring extended work shifts

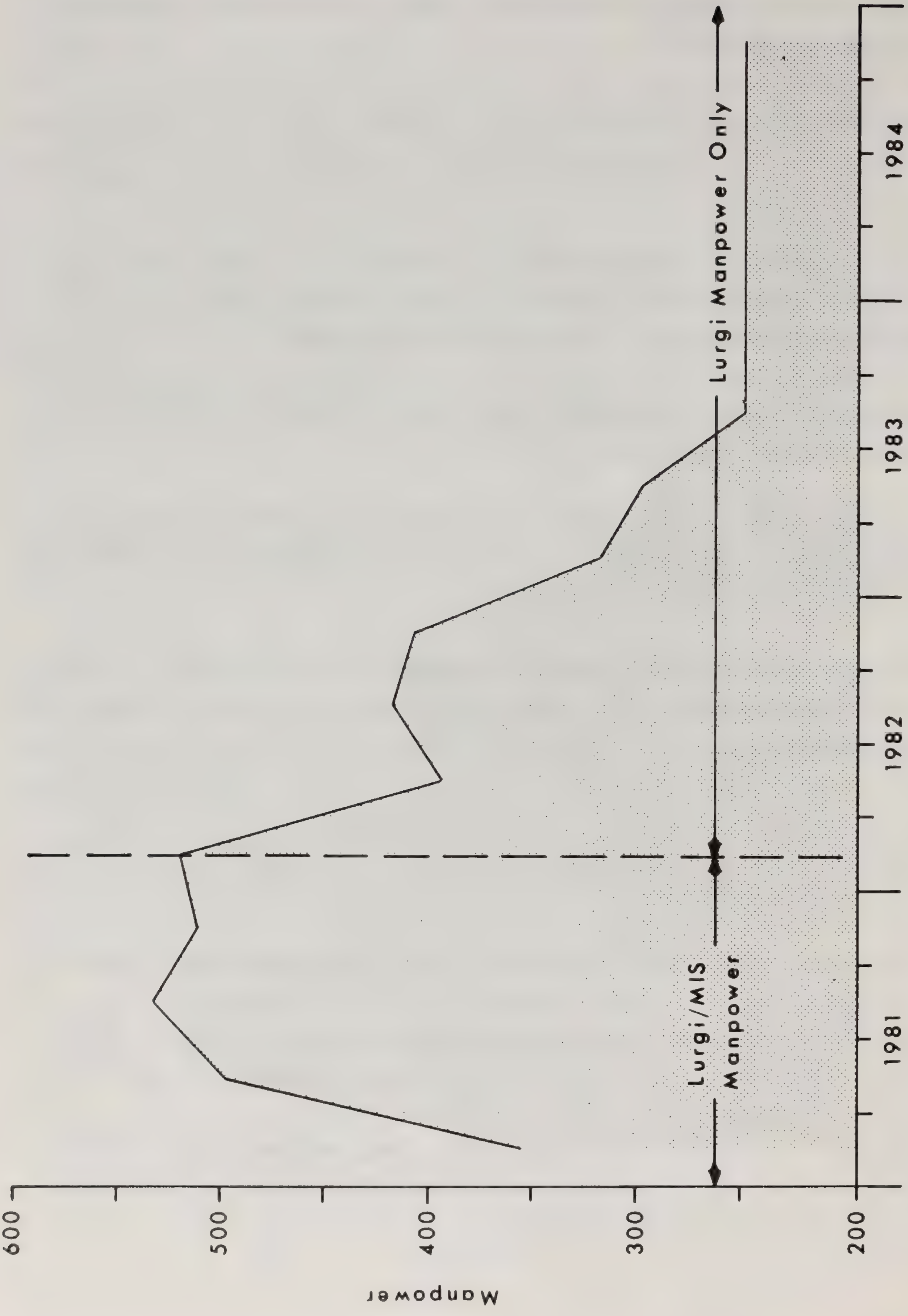



Figure 1-1-7
RBOSC Employment Projection

- Provide single-status housing for those employees who would prefer to live near the job during the week and then spend the weekend at home with their families

Another part of the housing effort is being pursued by exploring potential housing projects in Rifle, Meeker and Rangely among various developers in the private sector. Any plans developed between now and the completion of the MDP will be included in the housing plan.

In addition to RBOSC's own plans, group efforts to develop a healthy community atmosphere are being addressed by the Committee on Oil Shale of the Rocky Mountain Oil and Gas Association. A subcommittee formed in 1980 meets with local groups in various western slope communities to review potential needs and projects. RBOSC is very active in this organization.

RBOSC has participated since its inception in the Rio Blanco County impact mitigation CORE Committee. This committee is comprised of the county commissioners, a representative from both Meeker and Rangely, and a representative from each of the industrial developers expected to have impact on the County. The committee has received advice from the two advisory committees--the Eastern for Meeker and the Western for Rangely. They have identified impact problems needing attention and assisted the county commissioners in determining priorities for requests from the Oil Shale Trust Fund. RBOSC has also attended the meetings of the Garfield County CORE Committee which serves essentially the same purpose and functions as previously described for the Rio Blanco County CORE Committee.

The Oil Shale Trust Fund has provided significant assistance to Rangely and Meeker for schools, water system expansions, sewage treatment facility expansions, street and drainage projects, airport improvements, highway improvements, as well as supporting the Colorado West Area Council of Governments and planning efforts in the various communities. Through August 15, 1980, expenditures from the Oil Shale Trust Fund totaled $40,590,797, the majority of which went to Rio Blanco and Garfield Counties and their communities.

## 1.4 PERMITTING

Although RBOSC has obtained all necessary permits and other regulatory requirements to proceed with construction and operation of the MIS demonstration program, none of these permits are applicable to the Lurgi Demonstration Project. It was thus necessary to determine which specific permits approvals or modifications were required for construction and operations for this project. After these key regulatory requirements were identified, meetings were held with the agencies to review agency requirements and to determine the time needed to review and approve the permit applications to meet the schedule presented in 1.2B of this Section (Figure 1-1-6). The following is a list of the major regulatory requirements and the agencies involved.

Lurgi Demonstration Program Major Regulatory Requirements

| Agency | Regulatory Requirement |
|---|---|
| Oil Shale Office (USGS) | Modification to the Detailed Development Plan |
| Environmental Protection Agency | Prevention of Significant Deterioration (PSD) |
| Colorado Dept. of Health/ Air Pollution Control Division | Emissions/Fugitive Dust |
| Colorado Dept. of Health/ Water Quality Control Division | Surface Discharge (NPDES) |
| Colorado Dept. of Health/ Radiation and Hazardous wastes Control Division | Processed Shale Disposal Certificate of Designation |
| Colorado Dept. of Natural Resources Mined Land Reclamation Board | Regular Mining Permit |
| Rio Blanco County | Special Land Use Permit |
| Bureau of Land Management | Rights-of-Way/Temporary Use Permit |

In the past, RBOSC found that many problems were encountered in obtaining the necessary regulatory requirements for construction and operation in a timely manner. These included the vast array of permits, licenses, certificates, reviews, approvals and inspections; the overlap, conflict and duplication of regulations and missions of various Federal, State and local regulatory agencies; the lack of interagency coordination resulting in a time consuming process of sometimes having to seek major permit decisions one at a time; the necessity of having to wait until all individual agencies had been contacted before publicly announcing a project; and the lack of early public participation resulting from the previous problems.

Because RBOSC didn't begin to firm up its Lurgi Demonstration Project plans until mid 1980, it was necessary to look for a way to overcome the above-mentioned problems in order to achieve the objective of obtaining all necessary permits and approvals to allow construction to begin in the spring of 1981. (Because of the severe Western Colorado winters, it is necessary to begin construction as soon as weather permits in order to avoid high costs due to weather delays.) RBOSC decided to participate in the Joint Review Process in order to meet its time objective and overcome some of the regulatory problems previously described. The Colorado Joint Review Process, developed by the Colorado Department of Natural Resources, is a coordinated, inter-governmental review procedure for major energy and mineral resource developmental projects. The Joint Review Process offered an alternative to traditional project reviews by establishing a management system that coordinates the regulatory reviews of all participating agencies at all levels of government. It is important to note that the Joint Review Process works entirely within established regulatory requirements and does not attempt to alter any existing statutory requirements. It is anticipated that this management system will save RBOSC time and money since it encourages concurrent scheduling of regulatory processes rather than the traditional sequential process. The system has shown flexibility to date by acting upon RBOSC's new plans in the midst of its current MIS demonstration.

# Section 2

# MINING

# CHAPTER 1
# INTRODUCTION

Ore feed for the Lurgi retort will be provided both from the underground MIS mine and a surface mine. Underground ore will be limited to that oil shale produced during the development of Retorts Zero, One and Two and will be between 200,000 to 300,000 tons. The balance of the feed requirements will be provided from an open pit mining operation described here in Section 2. Also included are discusssions especially pertinent to the mining plan such as geology, hydrology and rock mechanics.

CHAPTER 2

SITE DESCRIPTION

## 2.1 LOCATION

The Lurgi Demonstration open pit mine is located in the extreme northwest corner of Tract C-a on the south side of Dry Fork. See Figure 1-1-5.

## 2.2 SIZE

The Lurgi demonstration open pit mine will produce 3.0 million tons of oil shale for Lurgi retorting. This will be accomplished in two phases. Phase I development will expose and mine 1.2 million tons of oil shale and Phase II development will expose an additional 1.8 million tons. Pit area disturbed by the Phase I development is approximately 24 acres and an additional 12 acres will be disturbed during Phase II for a total of 36 acres. Average existing surface elevation for the pit is 7,050 feet msl and the final pit bottom elevation will average 6,700 feet msl resulting in an average depth of 350 feet. The pit bottom elevation of 6,700 feet msl will be reached during Phase I with the pit increasing in areal extent only during Phase II operations.

The following discussion is limited to the geologic characteristics pertinent to the site-specific Lurgi Demonstration Project open pit area located in the northwest corner of the tract. Regional and Tract C-a geology is presented in detail in RBOSC Progress Report No. 5 on file at the OSO, Grand Junction, Colorado. A more condensed version is presented in Section 8, Chapter 2.

## 3.1 STRATIGRAPHY

Figure 2-3-1 shows the lines of two geologic cross sections which portray both the stratigraphy and structure in and adjacent to the open pit mine. These cross sections utilize subsurface control from nearby coreholes projected through the mine area and are identified as Sections A-A' and B-B' (Figures 2-3-2 and 2-3-3).

Both cross sections incorporate three key electric-log markers (middle A-groove, Blue and Orange markers) which are not only areally persistent within Tract C-a but also throughout most of the Piceance Creek basin. They are extremely reliable and useful in subsurface correlations.

The stratigraphy pertinent to the mine area consists of Quaternary alluvium and the underlying Green River Formation containing the oil-shale interval. Quaternary alluvium is limited to valley fill in the Dry Fork drainage north of the mine site. The Green River Formation is comprised of the Parachute Creek Member and the underlying Garden Gulch and Douglas Creek Members, the latter two being undifferentiated under Tract C-a. Generalized lithologic descriptions of these units are listed on Cross Section A-A' (Figure 2-3-2).

The total oil-shale interval in the mine area is about 1,230' thick and consists of 19 alternating relatively rich and lean zones. These zones are identified L-8 through L-00 in stratigraphically descending order with the relatively rich and lean zones designated "R" and "L", respectively. However, the Mahogany and A-groove zonal nomenclature is retained because of their well established usage.

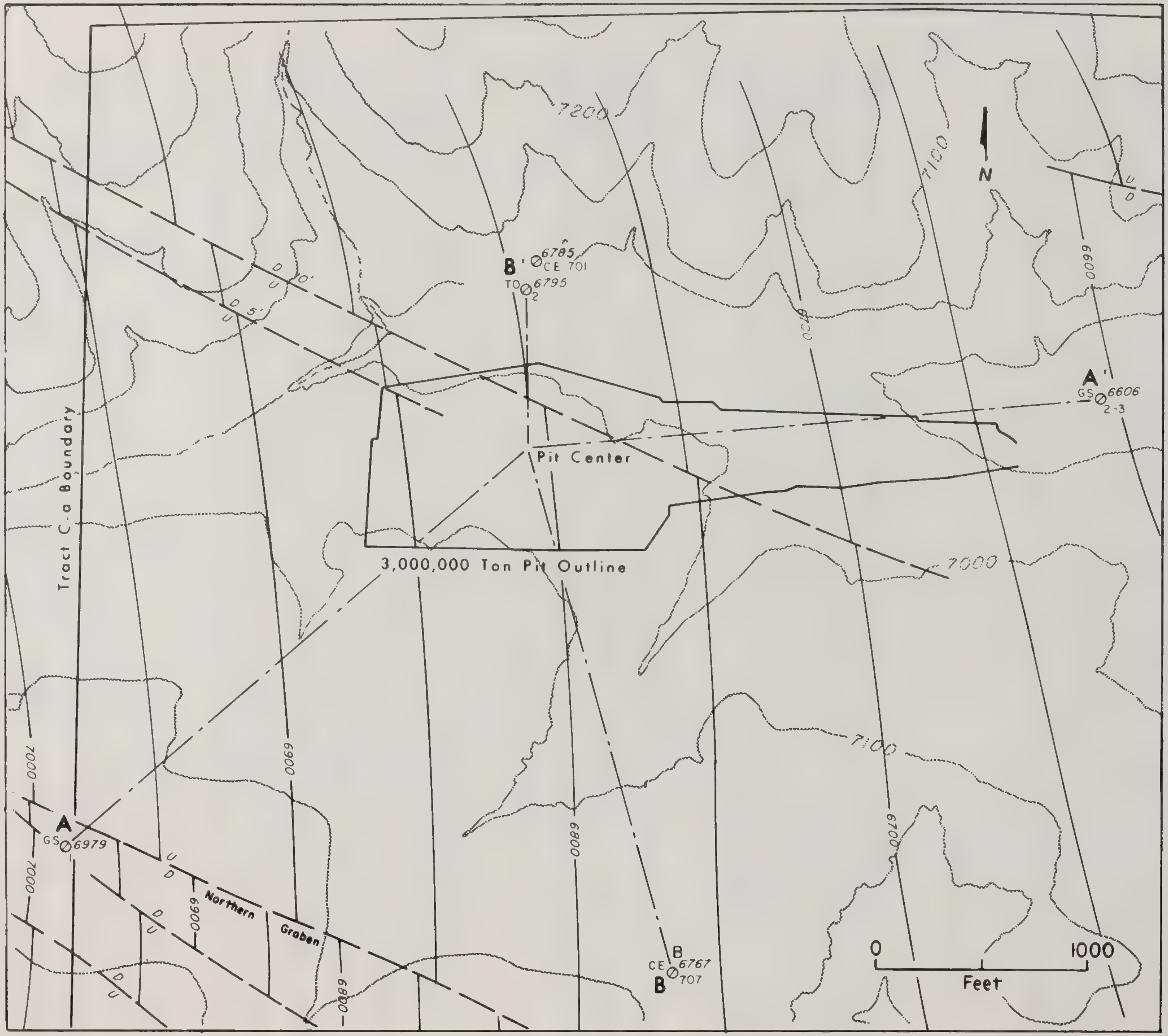



Figure 2-3-1

Middle 'A' Groove Structure C:I: Structure = 50' Topo = 100'

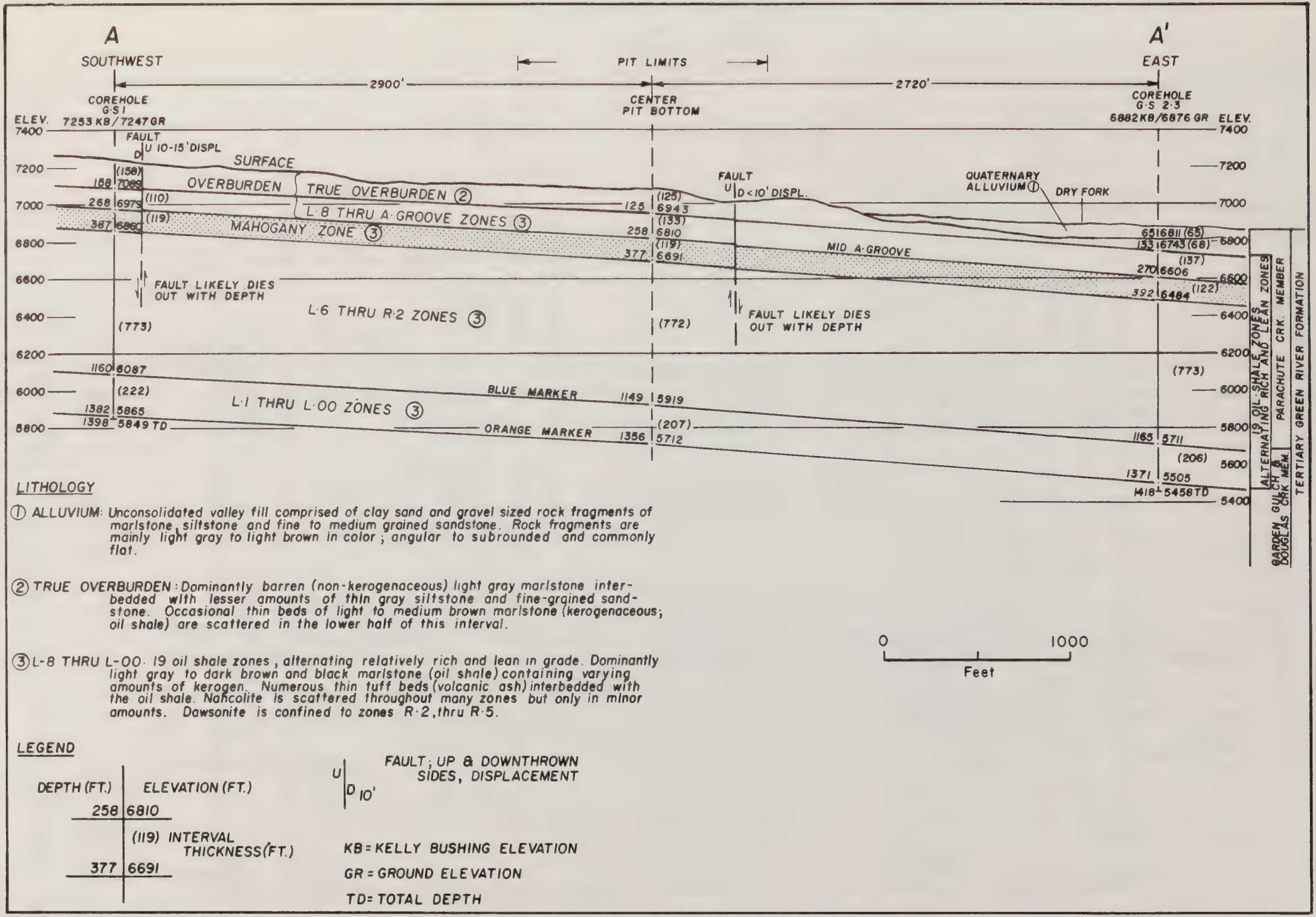
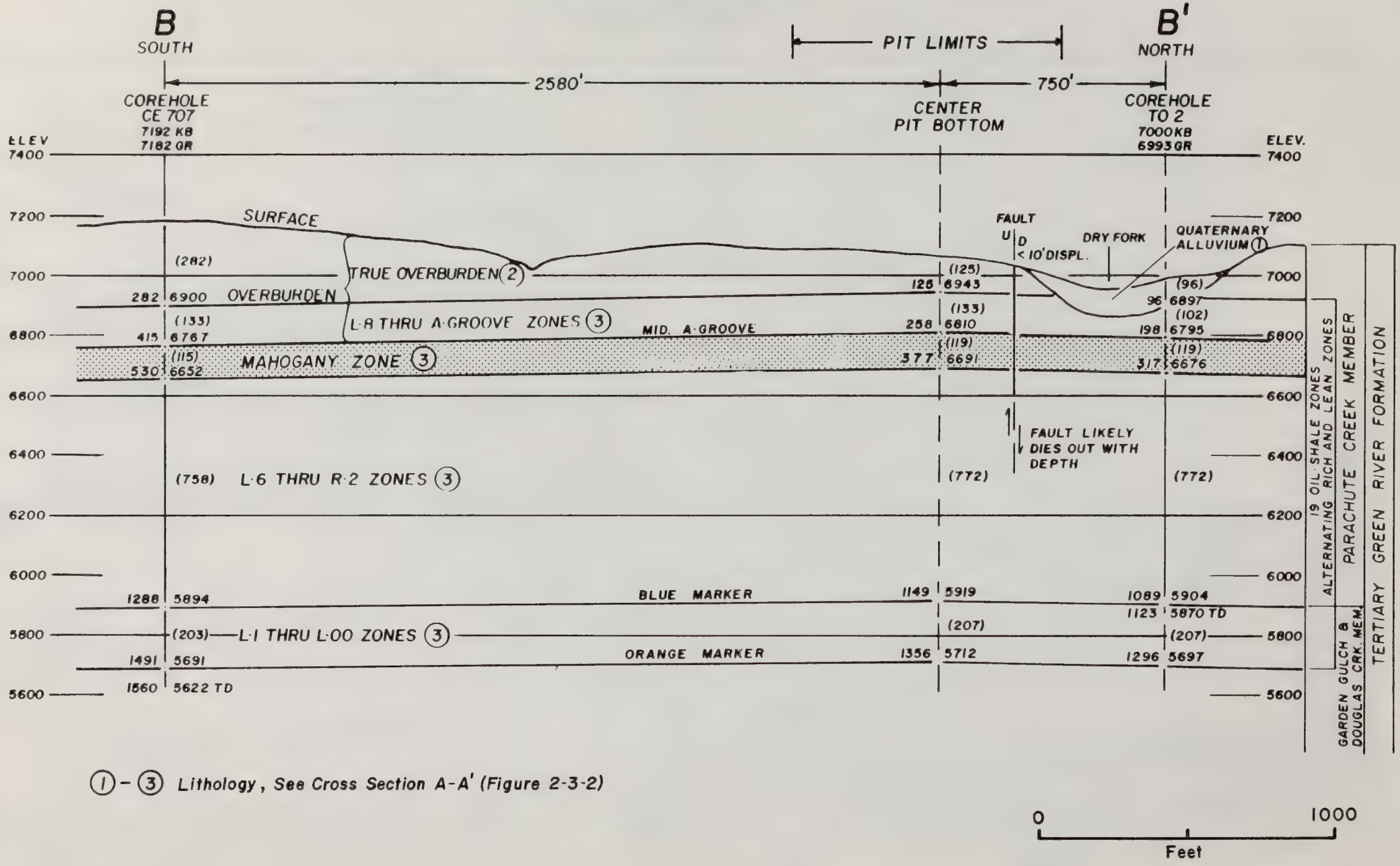



Figure 2-3-2
Cross Section A-A'




①-③ Lithology, See Cross Section A-A' (Figure 2-3-2)

Figure 2-3-3
Cross Section B-B'

Most of the total oil-shale interval (14 zones, L-8 through R-2) is within the Parachute Creek Member with a lesser fraction (5 zones, L-1 through L-00) in the underlying Garden Gulch and Douglas Creek Members. Stratigraphically above the total oil-shale interval are dominantly barren marlstones of the uppermost Parachute Creek Member.

The target oil-shale zone in the Lurgi demonstration open pit mine is the Mahogany zone with an average thickness of 114 feet. For the purposes of this demonstration project, the 3 zones above the Mahogany (L-8, R-8, A-groove) together with the barren uppermost Parachute Creek Member are classified as overburden. However, the location of oil shale from the R-8 zone will be defined in the overburden disposal area for potential recovery and processing at a later date. The 15 zones below the Mahogany (L-6 through L-00) will not be affected by this project.

## 3.2 STRUCTURE

Figure 2-3-1 portrays the structure of the open pit mine area based on photogeologic, surface geologic and subsurface corehole control. The horizon mapped is the middle of the A-groove, the key electric-log marker immediately above the Mahogany zone as shown on the cross sections of Figures 2-3-2 and 2-3-3.

The structure of the area is fairly simple. Beds generally dip about 4° (400'/mi) basinward to the east. The rather uniformly dipping beds are interrupted by only two minor parallel and southeast-trending step faults, both down to the north. Where well exposed on the northern slopes of Dry Fork, the two faults are vertical with displacements of only 5' and 10'.

These two faults are very likely shallow structural features which die out with depth and have limited extension into the subsurface similar to other surface faults mapped within the tract. For design purposes, these faults have been extended vertically through the planned pit as shown on the cross sections of Figures 2-3-2 and 2-3-3. Neither fault is considered detrimental to pit slope stability.

For a brief discussion of the joint patterns present in the mine area, refer to Section 2, Chapter 5.

## 4.1 REGIONAL AND TRACT HYDROLOGIC CHARACTERIZATION

Hydrologic characteristics of Tract C-a and vicinity have been studied during two years of extensive baseline studies and three years of MDP operation. Detailed descriptions of various components can be found in the RBOSP quarterly progress reports, the RBOSP Final Environmental Baseline Report for Tract C-a and Vicinity, 1977 and annual MDP monitoring reports. Also, results of regional investigations have been compared to those obtained at the site area. A summary and reevaluation of characteristics follows:

### A. Description of Meteorology and Climatology

1. Regional Characteristics - A number of precipitation and evaporation stations are located in the area near the RBOSC project. Those of most interest in the precipitation analysis are Grand Junction and Glenwood Springs, while those stations used in the evaporation analysis are Meridith, Green Mountain and Grand Junction.

Grand Junction is the only station in the region which has its own Local Climatological Data (LCD) provided by the National Climatic Center (NCC). This LCD is more comprehensive than the National Weather Service data. Although Grand Junction data are not strictly comparable to those from Tract C-a, due to differences in elevation and topography at the two locations, the Grand Junction LCD summary constitutes the longest known climatological record available in this area. Tabulated data based on up to 85 years of record are found in the NCC publication, 1975.

Grand Junction is located in a large mountain valley, at the junction of the Colorado and Gunnison Rivers, on the western slopes of the Rockies, and has a climate marked by the wide seasonal range usual to interior localities at this latitude. Relatively low precipitation occurs in the area because of the interior, continental location, ringed by mountains on all sides. Consequently, agriculture is dependent on irrigation, for which an adequate supply of water has been available from mountain snowmelt and rain runoff.

Summer rains occur chiefly as scattered light showers from clouds forming over nearby mountains. Winter snows are fairly frequent but mostly light and melt quickly. Even the infrequent snows of from four to eight inches, which are heavy for this locality, seldom remain on the ground for prolonged periods. Changes in winter are generally gradual, and abrupt changes are much less frequent than in eastern Colorado. Blizzard conditions in the valley are extremely rare.

Temperatures at Grand Junction have ranged from 105°F to -23°F, but readings of 100°F or higher are infrequent, and about one-third of the winters have no readings below 0°F. Summer days generally have maximum temperatures in the middle and low 90's and minimum temperatures in the low 60's. Relative humidity is very low in the summer, with daytime values averaging about 12% in August. Monthly pan evaporation rates range from unmeasurable in the winter to about 14 inches in July.

Visibilities of 20 miles or more and ceilings of 5,000 feet or higher prevail approximately 95 percent of the time. Gusty surface winds are frequent in spring and early summer. The prevailing wind is from the east-southeast due to the valley channeling effect, but the strongest winds are usually from the south and southwest and are generally associated with thunderstorms or with prefrontal weather.

2. Tract Characteristics - Although the Tract C-a area is hydrometeorologically similar to Grand Junction, it also possesses a number of unique characteristics. Elevations in the vicinity of Tract C-a range from 8,700 feet for some of the higher points along Cathedral Bluffs to the west and southwest of the site, to below 6,200 feet in some of the creek bottoms to the northeast. Distances from Tract C-a boundaries to these elevations are about 6 miles to the southwest, and 7 miles to the northeast, respectively.

During baseline studies, the USGS operated six rain gaging stations on and around Tract C-a (Figures 2-4-1 and 2-4-2). Three were storage type rain gages associated with the stream gaging stations near the west line of Tract C-a, on Dry Fork, Box Elder Gulch and Corral Gulch. Precipitation was manually measured at these stations at regular intervals. The remaining three rain gages were recording-type gages which record cumulative precipitation

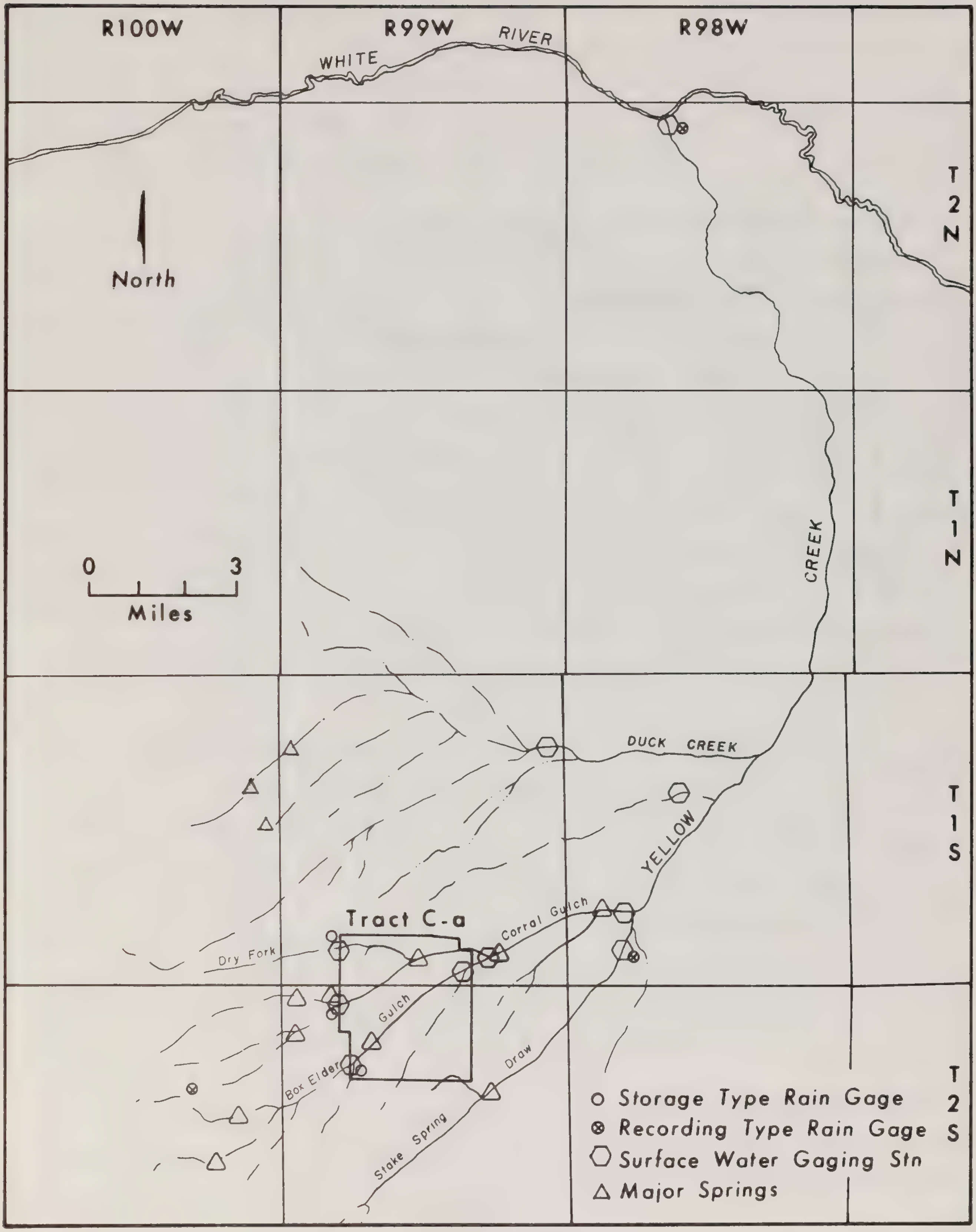



**Figure 2-4-1**
**Regional Surface Water Sampling Sites, Precipitation Gages, and Springs**

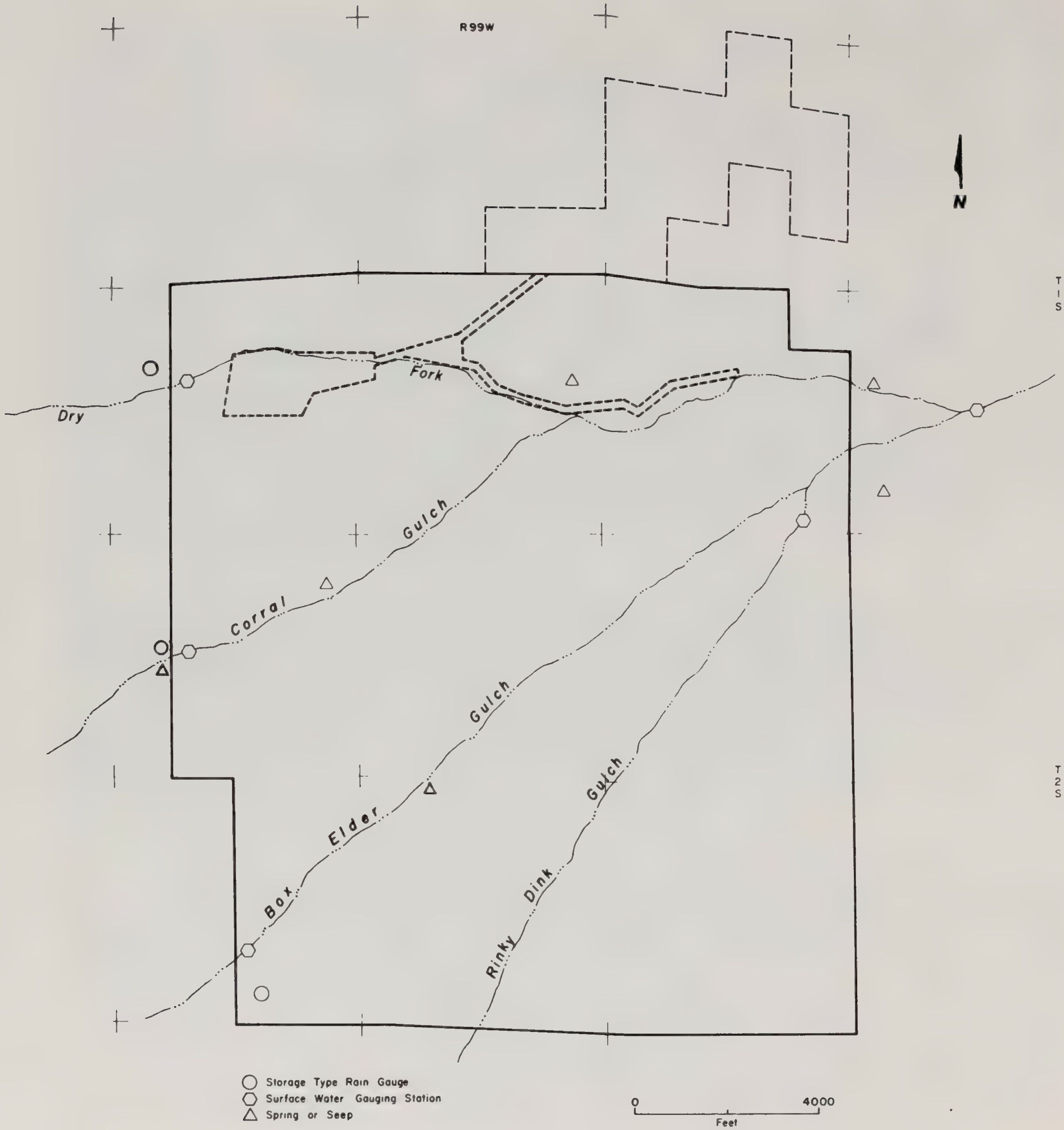



**Figure 2-4-2**
**Tract C-a Surface Water Sampling Sites**
**Precipitation and Springs**

as well as the precipitation rate over minimum five-minute increments. The recording station highest in elevation was the one about 5 miles west of the tract near the drainage divide on Cathedral Bluffs. The second highest was located near the surface water gaging station at Stake Springs Draw near its confluence with Corral Gulch about three miles east of Tract C-a. The third highest was at the surface water gaging station on Yellow Creek near the White River about 18 miles north-northeast of the tract.

The Tract C-a area is on a dissected plateau surrounded by high mountains. High-pressure cells often persist for several days, their passage blocked by the Continental Divide east of Tract C-a, deflecting low pressure systems around the region. As a result, there is a high frequency of clear sunny days with light winds and large diurnal temperature changes. Gradient winds are generally westerly, existing throughout the year, except when interrupted by the passage of frontal systems. Precipitation measurements indicate relatively low annual accumulations such as those of semi-arid steppe regions with the maximum amounts falling in the spring and summer. Over half of the seasonal precipitation falls as snow during late winter and spring. In addition, the data indicate a high degree of temporal and spatial variability in this area, which is to be expected, based on the rough terrain present with its variations in elevation and exposure.

Local topography within the Tract C-a area has a much more pronounced effect on surface air flows than the macroscale processes. Specific air movements produced by local conditions are often different from those expected from the major gradient flow. There is a tendency for wind velocities to be lowest at sunrise, when there is little vertical mixing due to thermal effects and the lower surface air is isolated from the higher velocity gradient upper air. Conversely, wind velocities are greatest in the early afternoon hours when the air exhibits its greatest tendency to move vertically due to terrestrial heating, and couples with the faster air moving above it.

By comparing regional and site-specific data, it is found that the Tract C-a temperature data are representative of the region. Also, Tract C-a data indicate that the visibility is greater than 20 miles for approximately 86 percent of the observations, giving good agreement with Grand Junction measurements.

Two basic weather systems affect precipitation in the study area. The frontal system generally results in widespread, uniform precipitation with a duration of a week or so. The convectional or thunderstorm system results in erratic precipitation amounts over an area of a few square miles, with a duration measured in hours.

a. Precipitation Design Data - The very short length of time over which precipitation data were gathered prohibited statistical analysis for engineering design values. By examining the nearby precipitation gaging stations, it was found that monthly precipitation accumulations were fairly constant throughout the region. Therefore, for some analyses, the historic data at the Glenwood Springs stations was assumed to be applicable to the site. The long term mean monthly precipitation histogram used for analyses is shown in Figure 2-4-3. In other cases in which storm event depths were needed, precipitation depth, duration, frequency curves were constructed using NOAA Atlas 2, Volume 3 for Colorado (see Figures 2-4-4 and 2-4-5). In 1978 a precipitation event similar in magnitude to the projected 25-year, 24-hour site event occurred in the neighboring Yellow Creek draingage, indicating the storms projected in the figures are realistically possible.

b. Evaporation Design Data - Pan evaporation was measured for a two-year period in 1975 and 1976 at Site 3, which is near the eastern boundary of Tract C-a in a low lying area. To supplement these data, seasonal pan evaporation readings were plotted versus elevation for various nearby stations. The resultant plot (Figure 2-4-6) clearly shows the variation of evaporation with elevation. The evaporation estimates were desired for sites located on upper elevation plateaus with relatively little wind protection, for which the Meridith gage is most representative and was therefore weighted most heavily. The monthly mean pan evaporation estimates were therefore based on this elevation-evaporation relationship. Values for April and October were derived from examination of temperature data and from experience in the western Colorado region (by discussions with consulting meteorologist Mr. Loren Crow, November 6, 1980). The monthly standard deviations for the site were estimated by calculating the standard deviations for

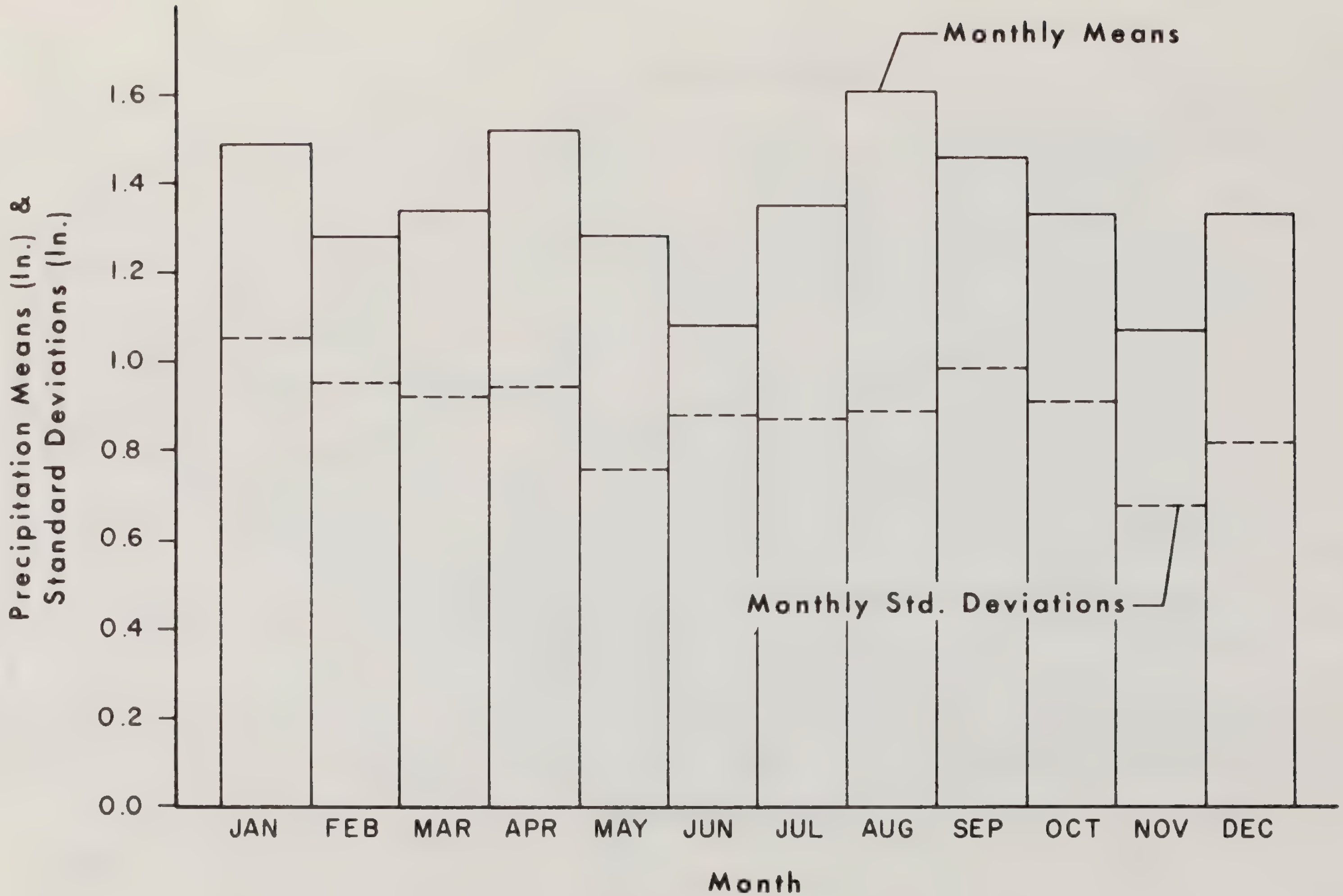



**Figure 2-4-3**
**Glenwood Springs Precipitation Histogram**

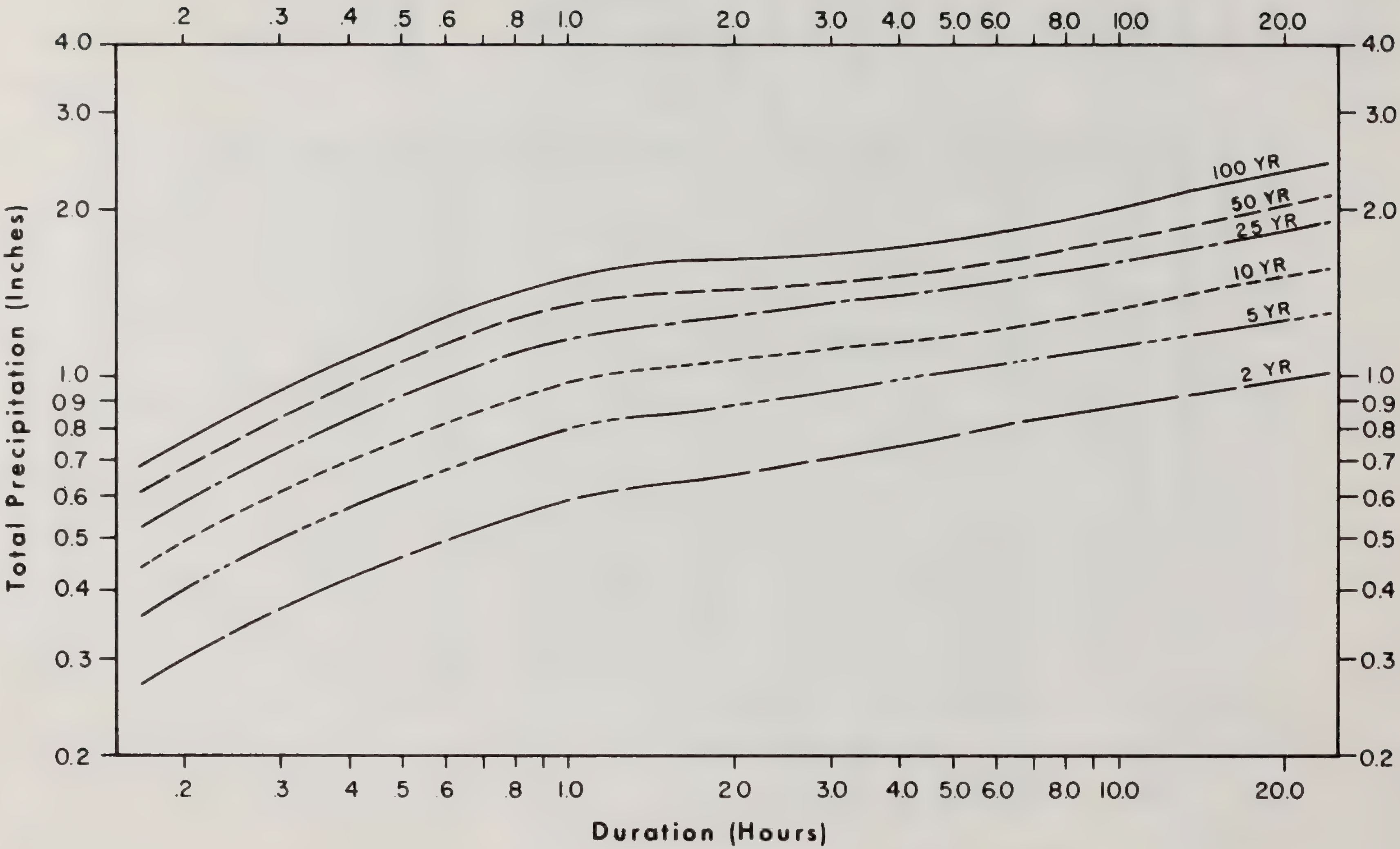



**Figure 2-4-4**
**Site Precipitation Depth-Duration-Frequency Curves (May-Oct)**

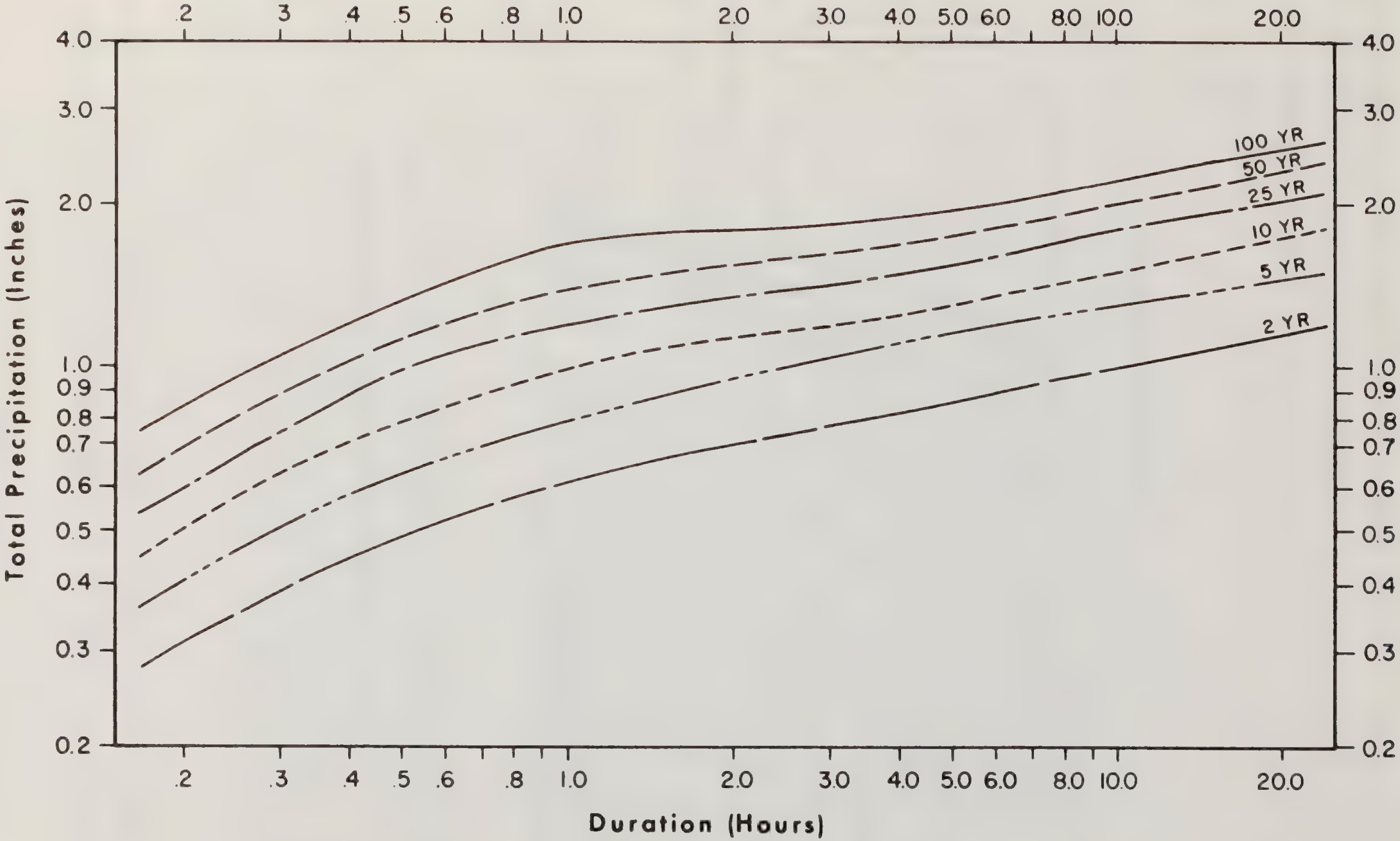



**Figure 2-4-5**
**Site Precipitation Depth-Duration-Frequency Curves (Annual)**

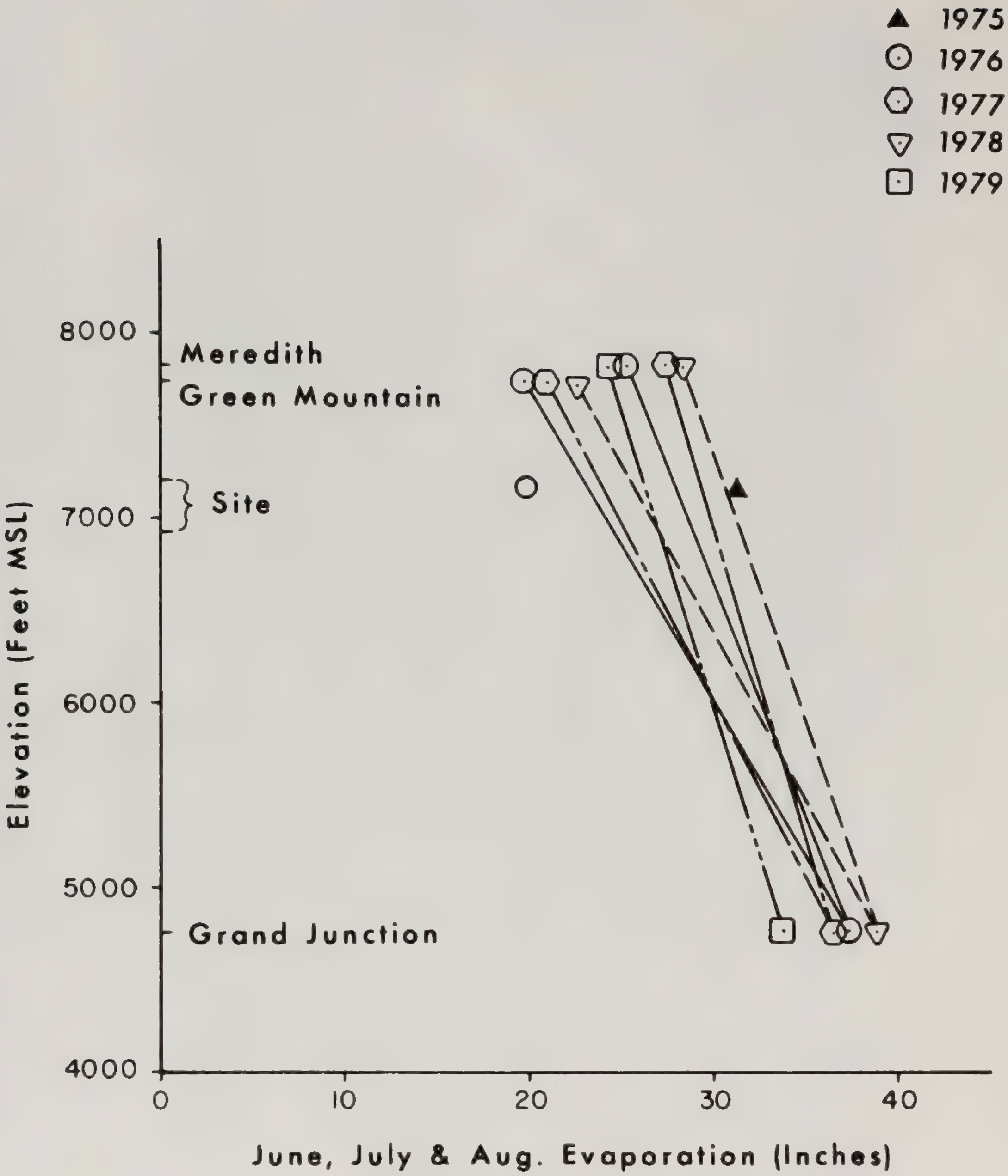



**Figure 2-4-6**
**Elevation vs Pan Evaporation Rates (1976-1979)**

the monthly data at Grand Junction and then multiplying by the ratio of the monthly mean evaporation estimates at the site to the monthly mean evaporation values at Grand Junction. The resultant pan evaporation histogram is shown in Figure 2-4-7. These evaporation values can be converted to pond evaporation by multiplying by the Class A pan coefficient. A pan coefficient of 0.7 is representative for this area, according to Weather Bureau Technical Paper No. 37.

B. Surface Water Hydrologic Description

1. Tract Hydrosphere - Tract C-a is located in northwest Colorado about 50 miles due north of Grand Junction. The tract occupies about 5,100 acres of pinyon-juniper and sagebrush rangeland. It is on the west flank of the Piceance Creek structural basin which is about 1,600 square miles in area. The edges of the basin lie near the rim of the Roan Plateau. Streams draining the exterior faces of the plateau are short, few in number, and have steep gradients. Piceance Creek and Yellow Creek and their tributaries drain most of the basin's interior and are longer and more gently sloping. The topography of the basin is characterized by a series of parallel north and northeasterly trending ridges and valleys.

2. Infiltration - Infiltration rates in a basin are influenced by four main factors: soil type, vegetation, land use, and soil moisture. The relationships of these factors to Tract C-a and the contributing drainage basins to the west follow.

a. Soil Types - Soil depths in the Tract C-a vicinity range in depth from as little as one foot on the ridges to alluvial fills as thick at 100 feet in the valley bottoms. Surficial soils generally range from loamy sands to clay loams. The physical properties of the surface and subsurface soils are typical of those in other semi-arid regions of the Western United States.

Preliminary soils maps and descriptions of soil types have been prepared for the tract area by both the Soil Conservation Service and the Colorado School

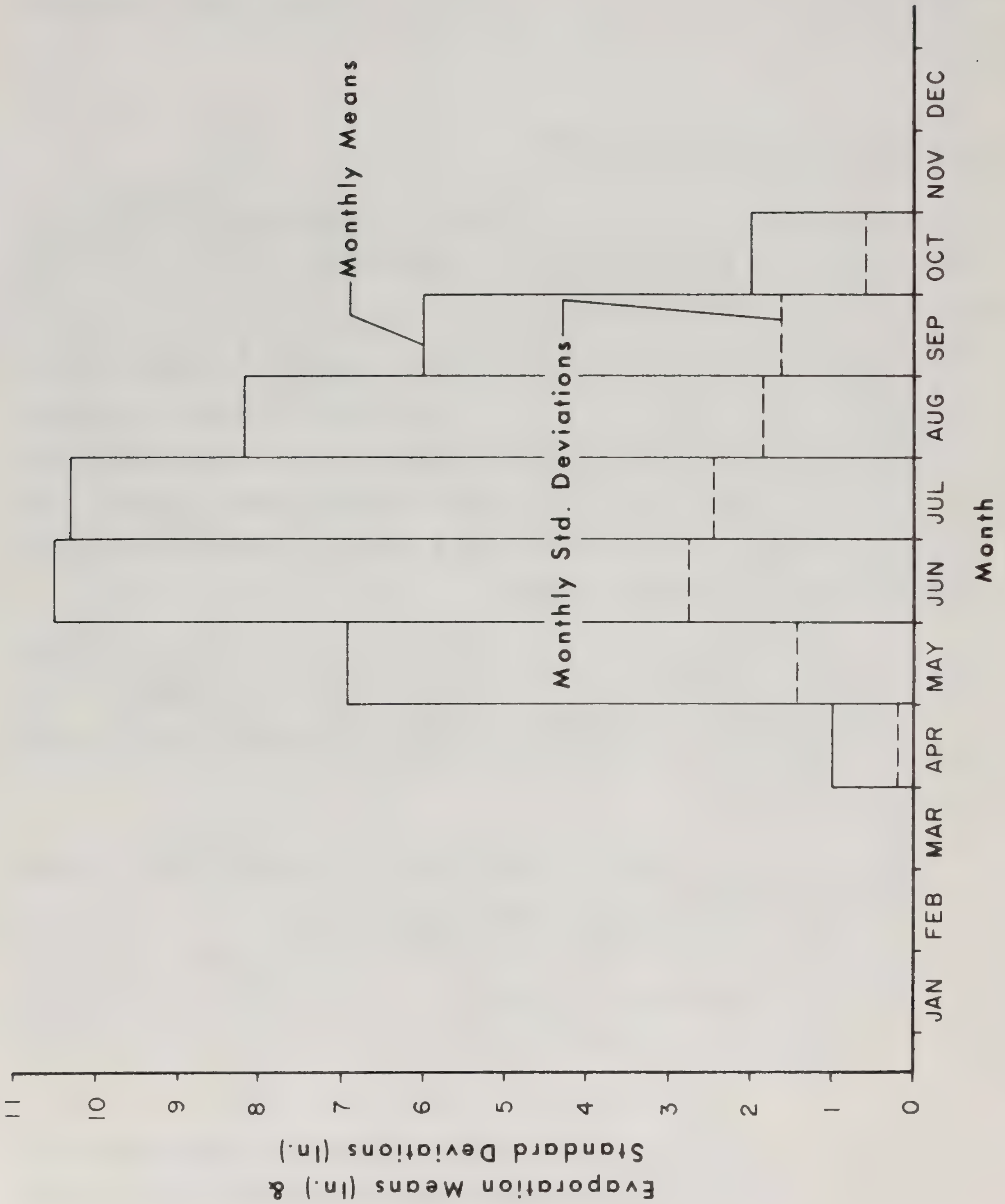



**Figure 2.4.7**
**Site Pan Evaporation Histogram**

of Mines Research Institute. These maps have been combined and refined to produce a tract area hydrologic soils map which is presented in Figure 2-4-8. The identified soil types (and their respective SCS hydrologic soil groups) present in the drainages upstream of Tract C-a are the Rentsac-Piceance (C-B), Redcreek-Rentsac (C-C) and the Rock Outcrop-Torriorthent (D) complexes, and the Glendive (B), Castner (C), and Havre (B) series.

On tract, all four hydroligc soil groups are represented by various different soil types. Soil type A is present in the Corral Gulch drainage near the east tract boundary and is represented by the Barcus series. Soil Type B is present in the alluvial areas and is represented by Glendive, Rivra and Yamac series. Soil type C is present in the ridge areas and is represented by the Rentsac-Piceance and Redcreek-Rentsac complexes and the Rentsac series. Soil type D is present as rock outcrops between the alluvial areas and the ridges and is represented by the Rock Outcrop-Torriorthent complex. In the upper part of the drainage basin relative amounts of soil types B and D increases, C decreases, and A is absent.

b. Vegetation - Vegetation in the area near the site is dominated by the pinyon-juniper association along with mixed brush and sagebrush. A list of all vegetation types found and their estimated land area coverage for the site and surrounding area is given in Table 2-4-1. A summary of the soils and associated vegetation types on Tract C-a and the Lurgi processing area is given in Table 2-4-2.

Table 2-4-1
VEGETATION TYPES IN AREA NEAR TRACT C-a

| Vegetation Types | Percentage of Area Covered | Soil Conservation Service Hydrologic Cover Quality Designation |
|---|---|---|
| Douglas fir (Conifer) | 2 | Good |
| Aspen (Broadleaf) | 1 | Fair |
| Mixed Brush | 25 | Fair |
| Pinyon-Juniper | 41 | Poor |
| Sagebrush | 27 | Poor |
| Greasewood | -- | Poor |
| Saltbrush | 1 | Poor |
| Riparian | -- | Good |
| Grassland | 2 | Good |
| Agricultural | 1 | Fair |
| | 100 | |

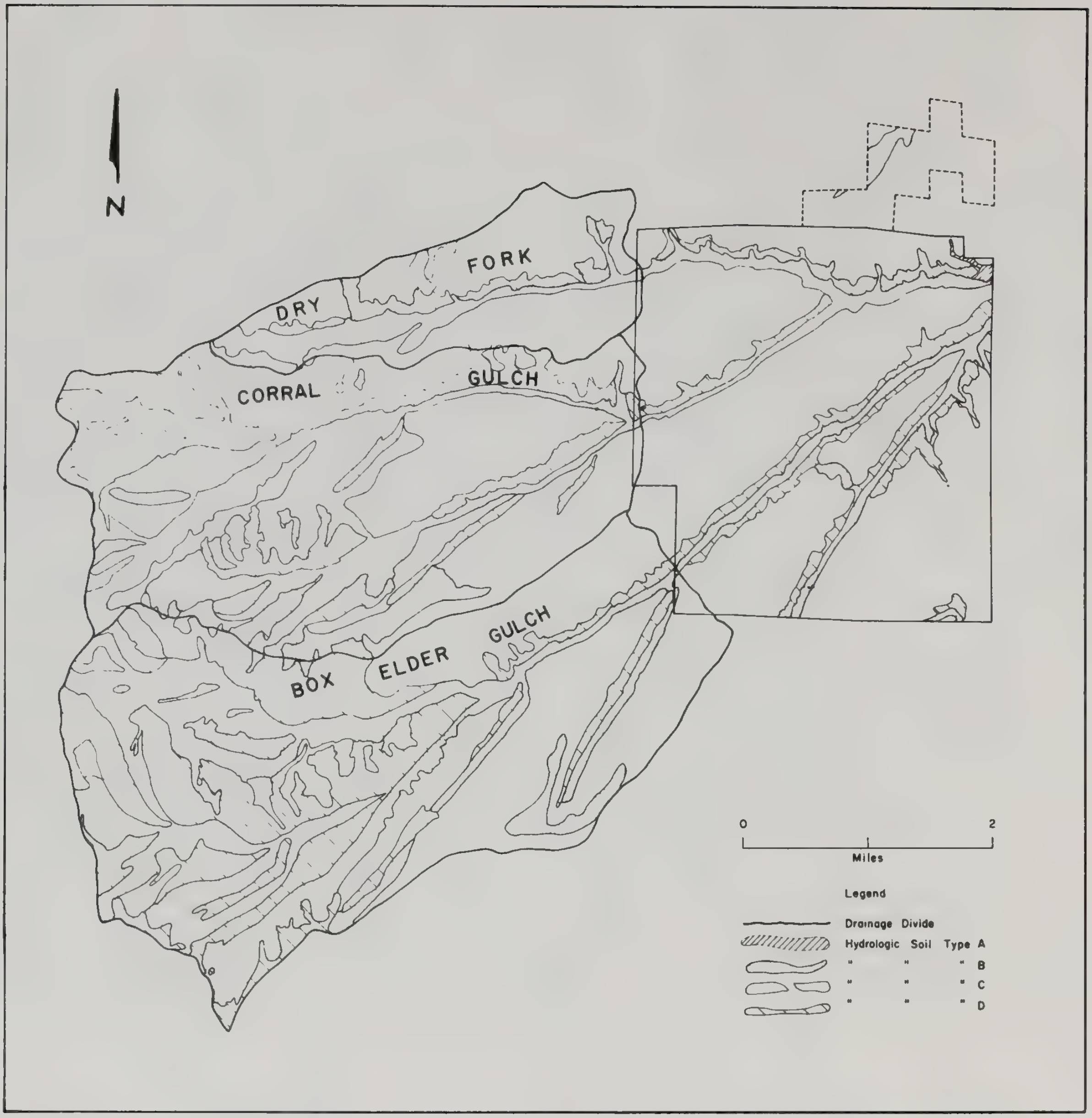



**Figure 2-4-8**
**Hydrologic Soil Types in Tract C-a Area**

Table 2-4-2

DOMINANT VEGETATION AND PERCENT OF AREA FOR EACH SOIL TYPE AT TRACT C-a AND LURGI PROCESSING AREA

| Dominant Vegetation Types | % of Tract | % of Lurgi Processing Area | Soil Type |
|---|---|---|---|
| Pinyon-Juniper, Sagebrush | 46 | 37 | Rentsac Series |
| Pinyon-Juniper, Sagebrush | 27 | 34 | Rentsac-Piceance Complex |
| Shadscale, Pinyon-Juniper | 11 | - | Rock Outcrop-Torriorthent Complex |
| Sagebrush, Rabbitbrush, Greasewood | 9 | - | Glendive Series |
| Pinyon-Juniper, Sagebrush | 6 | 19 | Redcreek-Rentsac Complex |
| Sagebrush, Rabbitbrush, Greasewood | 1 | 10 | Rivra, Yamac and Havre Series |
| | 100 | 100 | |

c. Land Use - Land use currently is confined largely to cattle grazing and big game hunting, as well as the development of energy and mineral resources. Most of the tract is BLM land with small parcels of DOW land interspersed among BLM holdings. The BLM controls cattle grazing in the area by means of grazing allotments. Tract C-a falls within the confines of two current grazing allotments. Scattered ranches and abandoned homesteads occur along the roadways leading into the tract.

d. Soil Moisture - As previously stated, a determining factor in defining the infiltration rate is the soil moisture. The variation of the soil moisture as a function of time has been defined by the SCS Curve Number method (SCS National Engineering Handbook, 1972). A basin weighted average curve number is derived by classifying the soil types into hydrologic soil groups, by estimating the type of vegetative cover, and by assuming some antecedent moisture condition (AMC). The AMC is based on the amount of rainfall in a period of 5 to 30 days preceding a particular storm. An AMC II, which is the average case for annual floods, was used in the flooding analyses of Dry Fork, Corral Gulch and Box Elder Gulch.

e. Infiltration Rates - Surface infiltration rates under saturated soil conditions have been measured by the Soil Conservation Service for the soil series present in the tract vicinity, using ring infiltrometers. Based on this data, infiltration rates over the site are expected to range from 2.0-6.0 inches per hour. Slightly lower rates (0.6-2.0 inches per hour) are expected in areas where Havre or Yamac Series are present. Essentially no infiltration is expected at rock outcrop areas.

3. Surface Water Flow - Tract C-a is drained by Dry Fork, Corral Gulch, and Box Elder Gulch. Surface water sources are limited to small intermittent streams and aquifer-fed springs and seeps. Normal yearly peak stream flows occur during spring snowmelt periods. Low flows occur in late summer or early fall.

Surface water quantity and quality have been measured at a number of locations in the RBOSC area as shown in Figures 2-4-1 and 2-4-2. Water flow has been continually monitored at six USGS gaging stations since 1974. These gaging stations' USGS numbers and tributary areas are given on Table 2-4-3. Each station consists of a control weir built across the stream for measuring discharge. In addition to the flow rate, temperature and conductivity were continuously monitored by automatic recording equipment.

Table 2-4-3
GAGING STATION IDENTIFICATION NUMBERS
AND DRAINAGE AREAS

| USGS I.D. No. | Location | Drainage Area Square Miles |
|---|---|---|
| 09306237 | Dry Fork near west line Tract C-a | 2.74 |
| 09306235 | Corral Gulch near west line Tract C-a | 8.61 |
| 09306240 | Box Elder Gulch near west line Tract C-a | 9.21 |
| 09306242 | Corral Gulch east of Tract C-a | 31.60 |
| 09306255 | Yellow Creek near White River, Colorado | 262.00 |
| 09306241 | "Rinky Dink" Gulch near east line Tract C-a | 2.39 |

Spring fed flow in lower Yellow Creek is tributary to the White River but upper Yellow Creek is dry most of the time. Streams on or near Tract C-a are intermittent with a few reaches showing a couple of miles of perennial flow from spring discharges. The data collected indicate that one major source of stream flow is snowmelt runoff. This runoff period is highly variable and has begun as early as February and as late as April. The streams are also subject to flooding due to high intensity summer thundershowers.

a. Design Flows - Three drainage basins were mathematically modeled to determine their flood flow characteristics using standard hydrologic techniques. These basins were defined above the USGS gages on Dry Fork, Corral Gulch, and Box Elder Guch, all near the west line of Tract C-a (see Figure 2-4-9).

The physiographic parameters were determined from USGS 7-1/2 minute quadrangles and are summarized in Table 2-4-4.

Table 2-4-4
BASIN PARAMETERS

| Parameter | Dry Fork | Corral Gulch | Box Elder Gulch |
|---|---|---|---|
| Drainage Area ($mi^2$) | 2.74 | 8.61 | 9.21 |
| Hydraulic Length (ft) | 19,000.00 | 27,700.00 | 33,000.00 |
| Curve Number | 65.00 | 63.00 | 62.00 |
| Time of Concentration (hr) | 0.78 | 1.00 | 1.20 |

The rainfall-runoff mechanisms were modeled using techniques presented in Urban Hydrology for Small Watersheds, SCS technical release No. 55, 1975 and an SCS Type II storm distribution as recommended in the March 1980 SCS publication, Procedures for Determining Peak Flows in Colorado. The resultant peak discharges are indicated in Table 2-4-5. A typical flood hydrograph is shown in Figure 2-4-10.

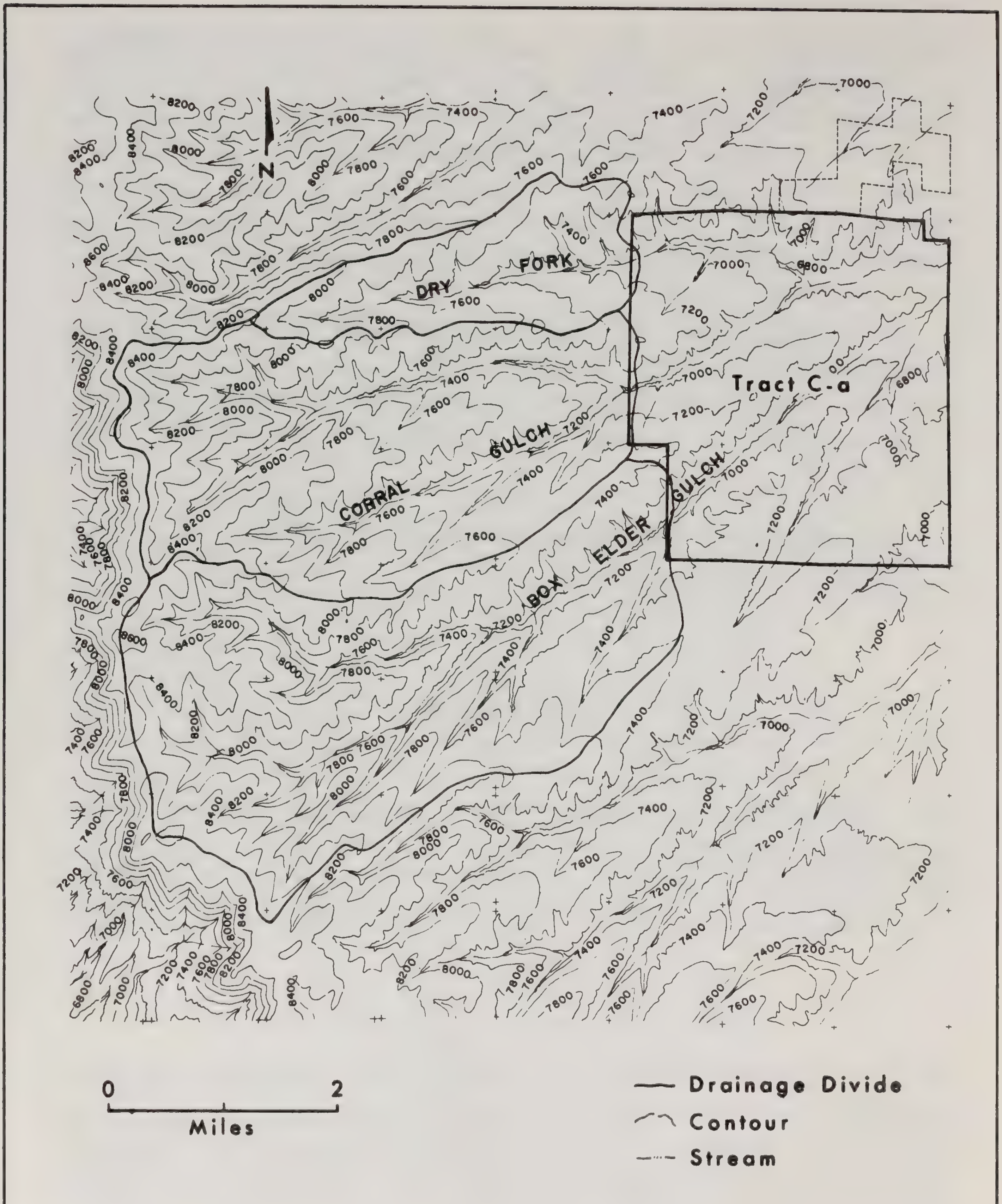



Figure 2-4-9
Tract C-a and Contributing Drainage Basins

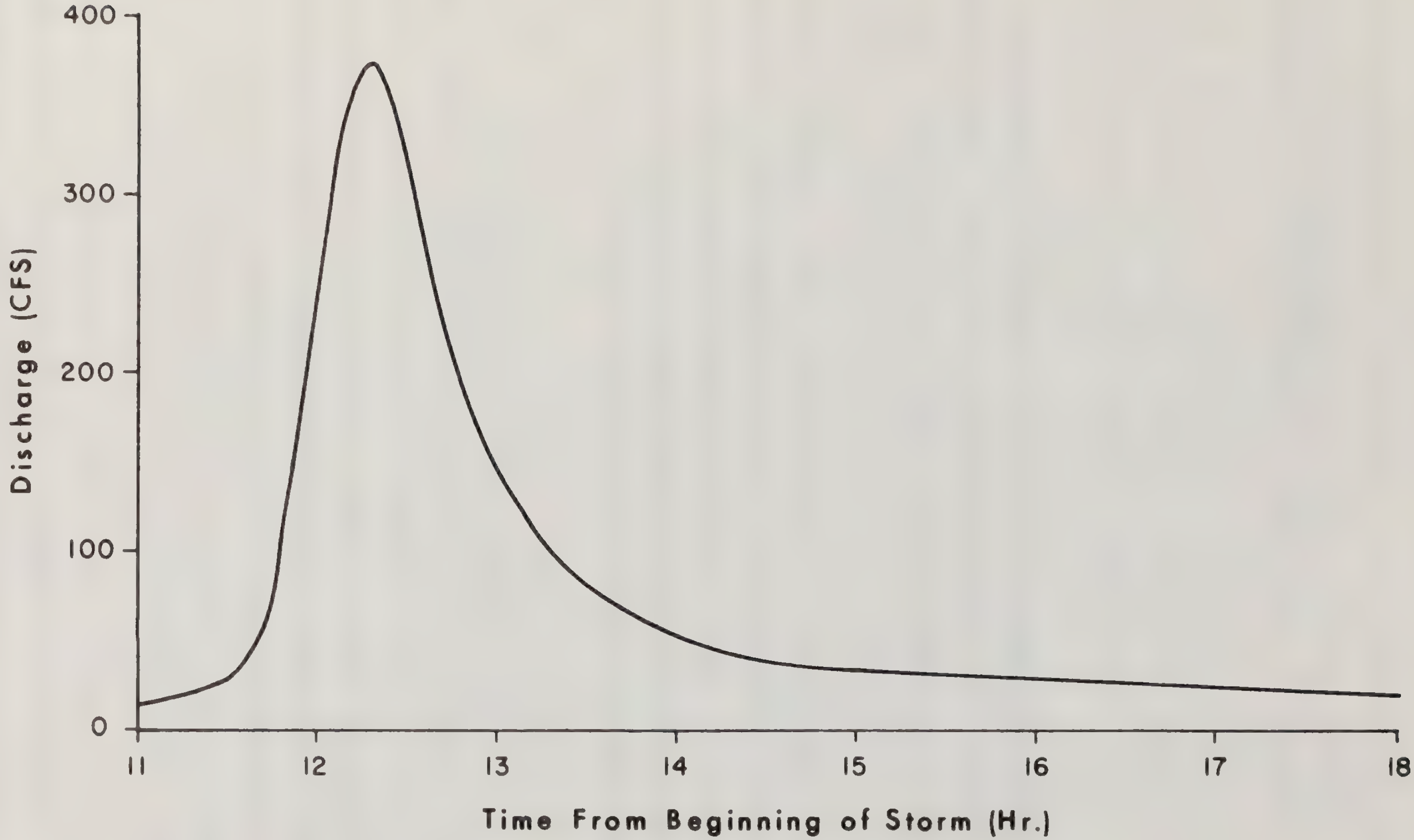



**Figure 2-4-10**
**Dry Fork 100 Year 24-Hour Storm Runoff Hydrograph**

Table 2-4-5

PEAK FLOW ESTIMATES

| Return Period (years) | 24-hr. Rainfall (inches) | Peak Flow (cfs) Dry Fork | Corral Gulch | Box Elder Gulch |
|---|---|---|---|---|
| 2 | 1.2 | -- | -- | -- |
| 5 | 1.5 | 33 | 54 | 29 |
| 10 | 1.8 | 99 | 162 | 143 |
| 25 | 2.1 | 176 | 351 | 315 |
| 50 | 2.4 | 286 | 567 | 544 |
| 100 | 2.6 | 374 | 756 | 715 |

b. Springs and Seeps - Thirty-seven springs and seeps were inventoried in the Tract C-a area during the baseline study. Major springs and seeps are shown on Figures 2-4-1 and 2-4-2. Some of these show intermittent or seasonal flows; more than 50 percent have perennial flows. These persistent flows may be derived from several sources, such as seepage from alluvial aquifers, the Upper Aquifer, or minor aquifers within the Uinta Formation or the upper Parachute Creek Member. Of the thirty-seven springs and seeps were collected as part of the thirty-five baseline aquatic resource sampling sites. These six stations were selected because they were the only ones from which the water came exclusively from the spring source.

The springs at Stations 1 and 2 have as their water source the alluvial aquifer, and the remaining stations, 3, 4, 5 and 8, derive their spring water from the Upper Aquifer or from recharge water entering the Upper Aquifer.

4. Water Quality - Surface water at Tract C-a is generally a very hard, alkaline water with dissolved solids concentrations averaging 600 milligrams per liter. Bicarbonate and sulfate are the dominant anions in solution and calcium, magnesium and sodium are the dominant cations. These five ions usually account for ninety percent or more of the total dissolved solids.

Tables of baseline surface water quality summaries for gaging stations on Tract C-a are presented by RBOSP Final Environmental Baseline Report for Tract C-a and Vicinity, Tables 2.10, 2.11, 2.12 and 2.13. Water quality data for on-tract gaging stations since baseline data collection ceased are presented in the various Modular Development Phase Monitoring Reports prepared biannually by RBOSC.

C. Ground Water Hydrologic Description - The ground water hydrologic system in the Tract C-a area is comprised of three important aquifers; three or more potential aquifers of lesser importance may exist in the area. The important aquifers include the alluvial aquifer, the Upper Aquifer, and the Lower Aquifer. Other potential aquifers may include limited water-bearing strata within the Uinta Formation, the upper Parachute Creek Member (above the Upper Aquifer), and bedrock aquifers below the Lower Aquifer.

1. Alluvial Aquifer - Unconsolidated Quarternary sediments representing a combination of alluvial and colluvial deposition are present in the valleys and on the flanks of all of the major drainageways within Tract C-a. Figure 2-4-11 shows the approximate extent of alluvial deposits within the tract.

a. Thickness - The thickness of alluvial deposits within the tract ranges from 0 to about 100 feet thick. Within the major drainageways, Corral Gulch, Box Elder Gulch, Stake Springs Draw and Dry Fork, the alluvial deposits are generally 40 to 100 feet thick. Alluvial materials have been studied in detail only in Dry Fork. Figure 2-4-12 shows the thickness of alluvium in Dry Fork.

b. Hydraulic Properties - The results of the alluvial monitoring program indicate that all of the major drainage systems, with the possible exception of Dry Fork, have water-saturated alluvium and that in many of the minor drainage systems the alluvium is dry. Monitoring data for observation wells in the major drainage systems indicate a seasonal trend in the water levels. This trend shows rising water levels during the snowmelt runoff period and declining water levels the remainder of the year. Continuous water level records indicate that the alluvial aquifer water table elevations are only indirectly affected by regional and local precipitation events.

The number of available monitoring points in drainageways which contain saturated alluvium is insufficient for preparation of water level contour maps. An alternate data presentation is shown on Table 2-4-6.

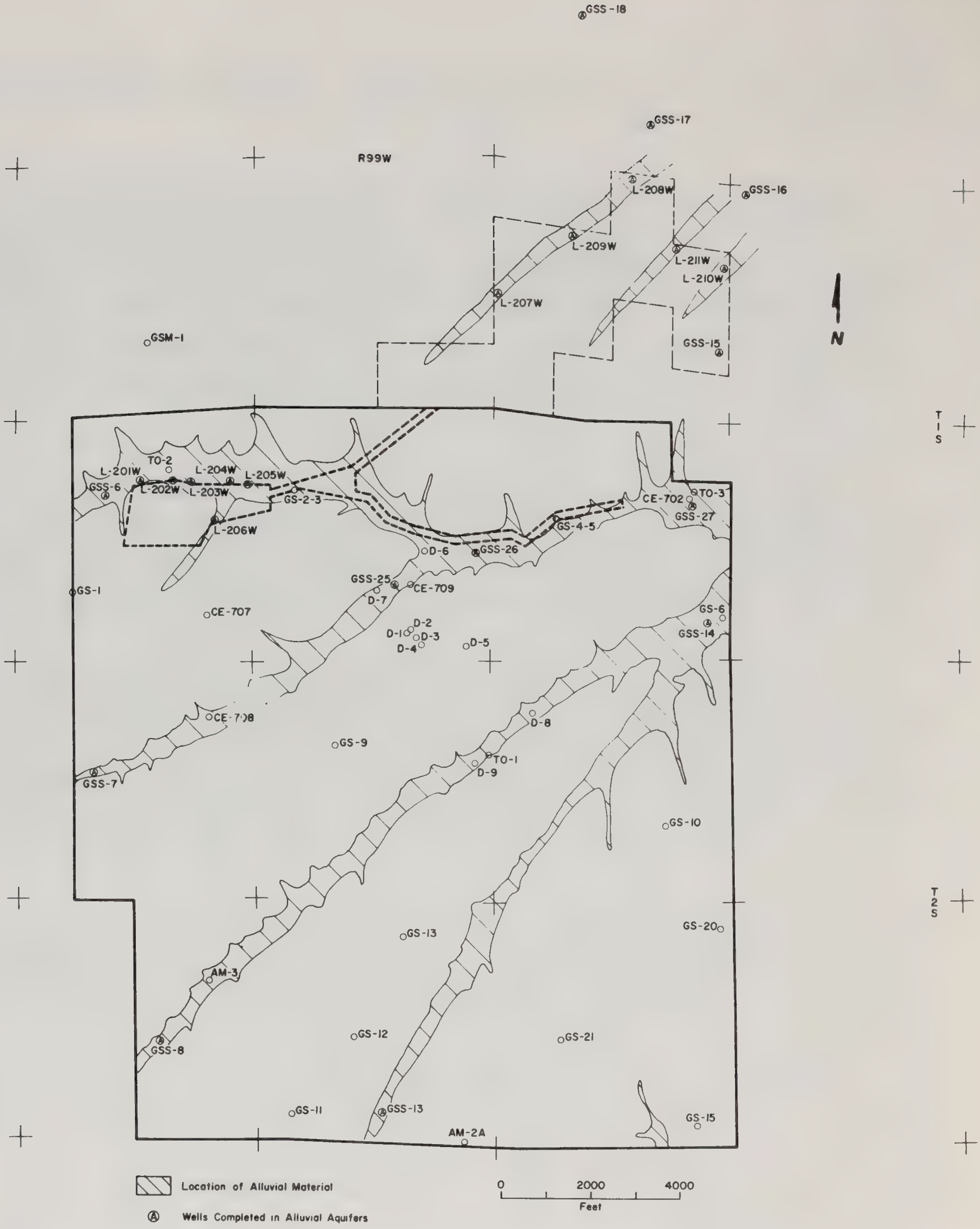
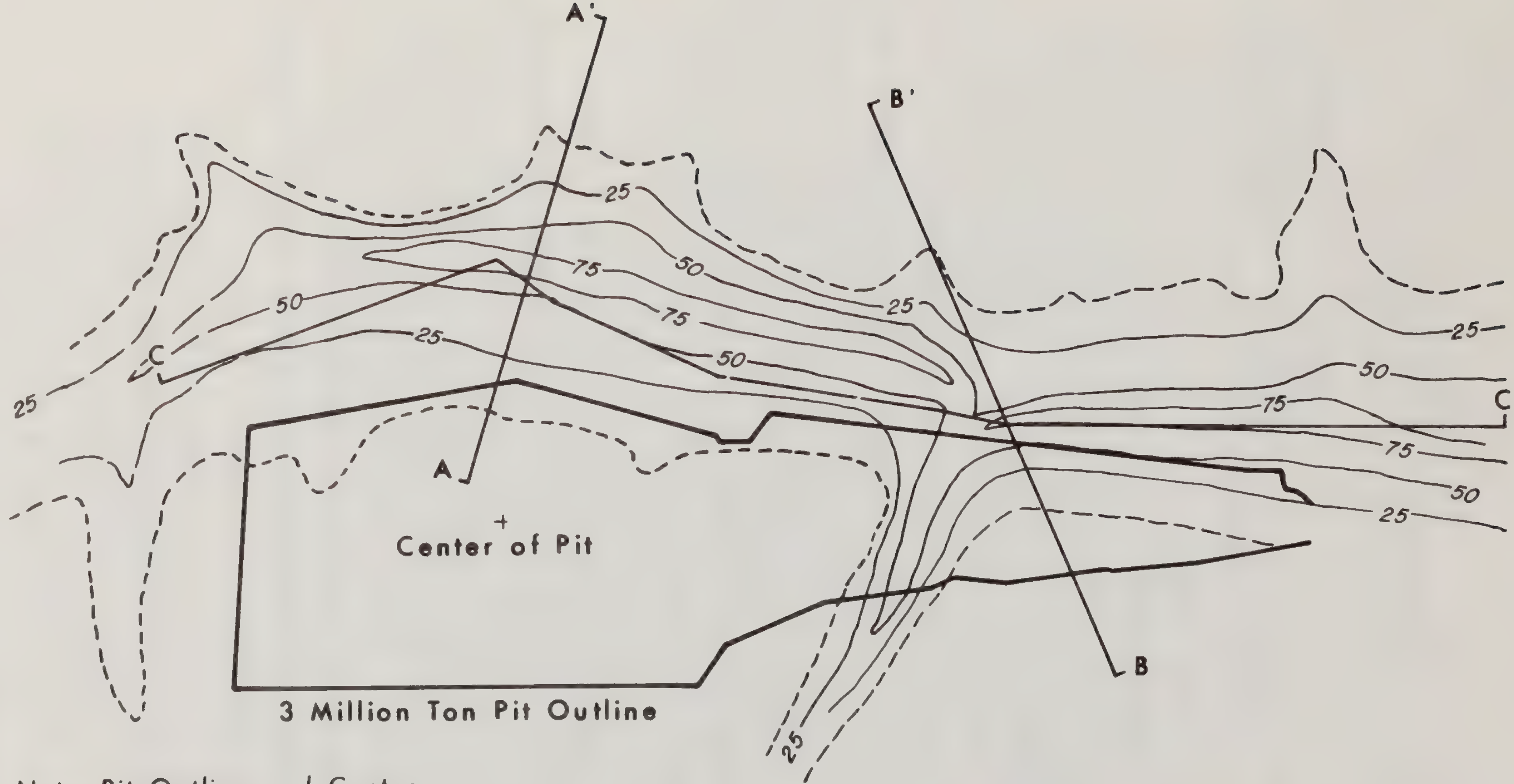



**Figure 2-4-11**
**Extent of Alluvial Materials**




Note: Pit Outline and Center From Drawing Titled "Geology of Lurgi Demonstration Open Pit", Figure G-119, File E-13, Dated 11/3/80 by RBOSC.

0 — 1000
Feet

Extent of Alluvium
75 Contours of Alluvium Thickness

**Figure 2-4-12**
**Thickness of Alluvium in Surface Mine Area**

Table 2-4-6

ALLUVIAL AQUIFER MONITORING DATA

| Hole | Location | Depth of Well (feet) | Mean Static Water Level (depth in feet) |
|---|---|---|---|
| G-S S-7 | Box Elder Gulch | 44 | 21.6 |
| G-S S-8 | Corral Gulch | 50 | 35.7 |
| G-S S-11 | Corral Gulch* | 66 | 44.0 |
| G-S S-12 | Yellow Creek* | 87 | 32.6 |

* Off-Tract locations.

Hydrologic testing has not been performed on the alluvial aquifer within the tract. Basin-wide testing indicates that the hydraulic conductivity of unconsolidated alluvial deposits in major valleys is high and is reflected in transmissivities of 20,000 to 150,000 GPD per foot. Because the alluvium is unconsolidated and water occurs under unconfined conditions, storage coefficients are estimated to be about $2 \times 10^{-1}$.

c. Water Quality - Baseline data for alluvial aquifer water at Tract C-a generally indicate a very hard, slightly acidic water with dissolved solids concentrations averaging 780 milligrams per liter. Bicarbonate and sulfate are the dominant anions in solution and sodium is the dominant cation. These three ions account for approximately ninety percent of the total dissolved solids. Additional data, collected after baseline sampling was completed indicate that chemical changes have occurred. 1980 data indicate slightly alkaline water with higher average TDS concentrations than were recorded during baseline studies.

Baseline ground water quality of alluvial aquifers on Tract C-a is summarized in RBOSP Final Environmental Baseline Report for Tract C-a and Vicinity, Table 2.80. Water quality data collected after the completion of baseline studies are presented in the various Modular Development Phase Monitoring Reports prepared by RBOSC.

d. Recharge-Leakance Mechanisms - In the tract area, recognized recharge mechanisms include direct infiltration of precipitation, mainly spring snowmelt, infiltration of surface water flow and leakage from underlying bedrock aquifers. Figure 2-4-13 illustrates the close association between surface water flow and alluvial aquifer water level. The seasonal response of both to snowmelt is also apparent.

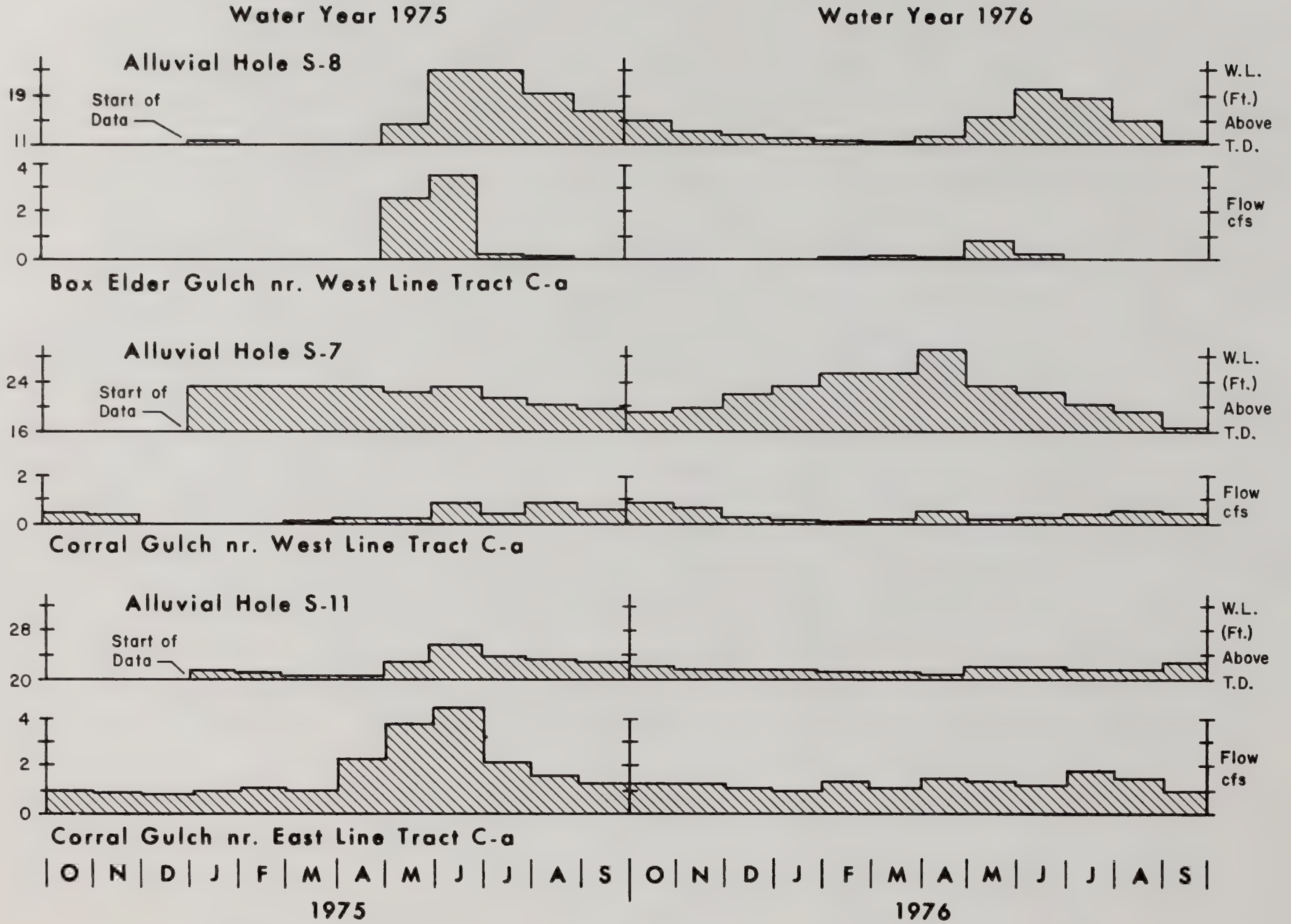
Several springs or seeps have been identified in the Tract C-a area, including six within or near the tract boundaries. The flow from most of these has been attributed to discharge from the Upper Aquifer or from recharge water entering the Upper Aquifer. In addition, it is considered that the Upper Aquifer discharges into the base of the alluvial aquifer along major fractures in the discharge areas of the basin. Together, these sources represent significant recharge to the alluvial aquifer.

Leakage from the alluvial aquifer occurs as discharge to the surface water system at possibly two of the six study springs. Additional leakage probably occurs as downward migration of water from the alluvium into underlying fractured sandstone, marlstone, and oil shale in the recharge areas of the basin.

2. Bedrock Aquifers

a. Terminology - A description of aquifers in the Uinta and Green River Formations is presented by the USGS in Simulated Effects of Oil-Shale Development on the Hydrology of Piceance Basin, Colorado, Professional Paper 908, (Weeks, et al, 1974). That publication defines the Upper Aquifer in the Piceance Basin as the interval between the Mahogany zone and the ground surface. This interval includes both the Parachute Creek Member and the Uinta Formation. The Lower Aquifer is defined as the fractured and permeable portion of the Parachute Creek Member below the Mahogany zone. The Mahogany zone itself is recognized as an interval of reduced vertical permeability which acts as a leaky confining layer between the two aquifers.

A different aquifer definition has been traditionally utilized by RBOSC on Tract C-a. The Upper Aquifer has been identified on tract as a zone closely




Source: RBOSC Final Environmental Baseline Report for Tract C-a and Vicinity, 1977.

Figure 2-4-13
Alluvial Monitoring Well Water Levels Versus Streamflow

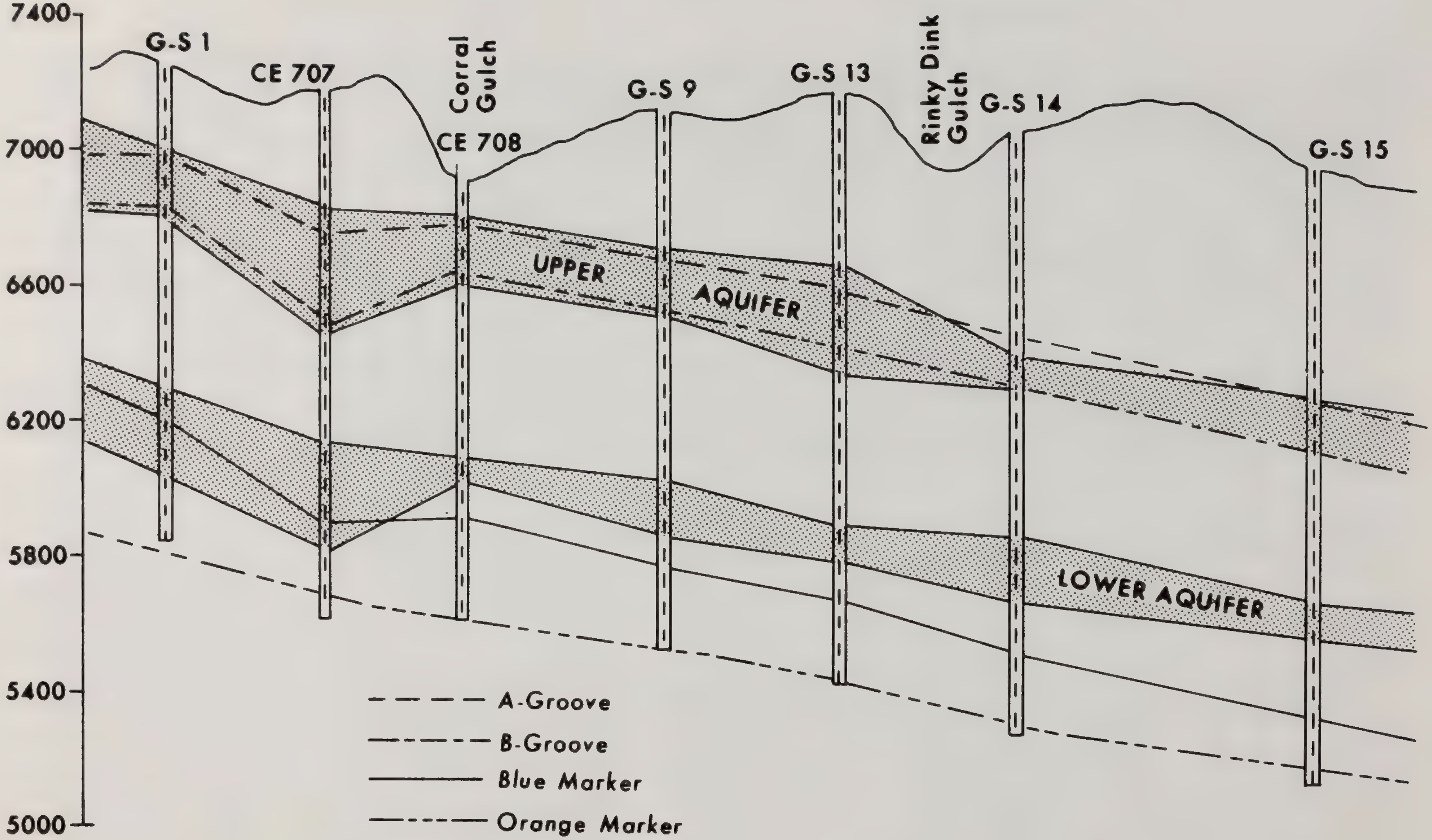
associated with the Mahogany zone, extending a limited stratigraphic distance above and below it. As utilized by RBOSC, the Upper Aquifer straddles the USGS Upper Aquifer-Lower Aquifer boundary. The RBOSC Lower Aquifer occurs in the leached zone in the lower Parachute Creek Member. This interval coincides with the lower portion of the Lower Aquifer as designated by USGS.

The RBOSC aquifer designations are utilized in this report. Figure 2-4-14 illustrates the positions of these aquifers.

b. Upper Aquifer - The Upper Aquifer traditionally has been defined on Tract C-a as water-bearing zones of similar water quality and temperature characteristics with an upper stratigraphic limit above the Mahogany zone and a lower limit below the B-groove. Evaluation of available data indicates that the interval traditionally referred to as the Upper Aquifer is actually comprised of two water-bearing zones, one above and one below the Mahogany zone. Aquifer test data indicate that the Mahogany zone is an interval of low vertical permeability ($15 \times 10^{-7}$ feet per day) and is actually an aquitard confining above it a water-bearing zone associated with the A-groove and below it a water-bearing zone associated with the B-groove.

Both portions of the Upper Aquifer occur in similar lithologies, primarily fractured oil shale and marlstone. Primary porosities in these rocks are very low. Secondary porosity is significant and occurs as fractures and vugs. The Mahogany zone has a similar lithology; however, the concentrated organic materials in the oil shale have allowed the unit to respond plastically to deformation and, therefore, fracture development is less extensive than in the lean oil shales above and below it. In addition, organic materials have, to some extent, filled the secondary porosity which did develop.

The majority of Upper Aquifer monitoring and hydrologic testing on Tract C-a has been performed in wells which are completed within the entire aquifer as it is traditionally defined. Thus, available data represent the hydraulic properties of a composite aquifer which contains the A-groove water-bearing zone, the B-groove water-bearing zone, and the Mahogany zone aquitard. For this reason, discussions in this report deal with the Upper Aquifer as it has




*Base of Lower Aquifer Source:*
*RBOSC Final Environmental Baseline Report*
*for Tract C-a and Vicinity, 1977*

**Figure 2-4-14**
**Principal Bedrock Aquifers Beneath Tract C-a**

previously been defined by RBOSC. Further hydrologic evaluation will be required to delineate the specific properties of the components of the Upper Aquifer.

1) Aquifer Character - The positions of the top and bottom of the aquifer are dependent upon secondary porosity and correlate only generally with specific stratigraphic horizons. The position of aquifer boundaries have been established by analysis of water production records made during drilling of exploratory boreholes, temperature and fracture description of core samples, and temperature and flowmeter logs. In general, the top of the aquifer occurs in the R-8 zone, above the A-groove and the base occurs in the R-6 zone, below the B-groove.

The structural configuration of the top of the Upper Aquifer is illustrated on Figure 2-4-15. As is shown on this map, the Upper Aquifer is broken and offset by several faults. Fault displacements measured at the surface are between a few feet and a few hundred feet. The hydraulic significance of Upper Aquifer faulting has been confirmed by hydrologic testing and is discussed below. Upper Aquifer depth below the ground surface varies from about 100 to 300 feet beneath the valleys to from 250 to 900 feet beneath the ridges. The Upper Aquifer is closest to the surface in Corral Gulch and Dry Fork in the northwest portion of the tract.

Aquifer thickness is shown on Figure 2-4-16. Thickness varies from less than 100 feet to over 300 feet, and averages about 200 feet.

2) Hydraulic Properties - Upper Aquifer hydraulic parameters were determined through a large number of short duration aquifer tests and one long duration test. The average transmissivity reported from short-term tests was 15,000 GPD per foot and the average storage coefficient was $6.8 \times 10^{-5}$. Evaluation of MDP pumping data indicates that these values of transmissivity and storage coefficient are respectively high and low and that average values of 6,000 GPD per foot and $10^{-3}$ respectively may be more accurate. Values of transmissivity and coefficient of storage computed from

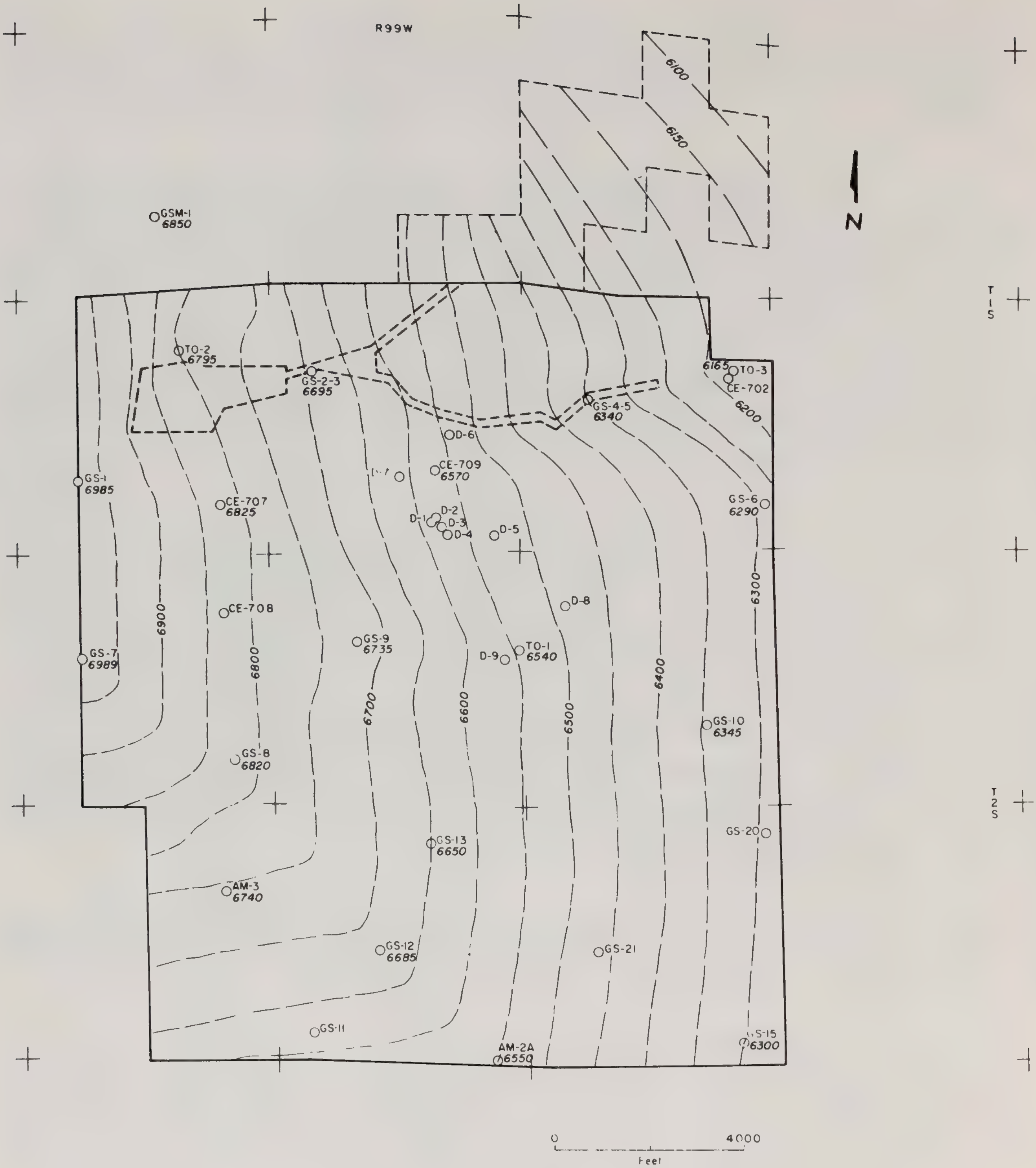



Figure 2-4-15
Topof Upper Aquifer

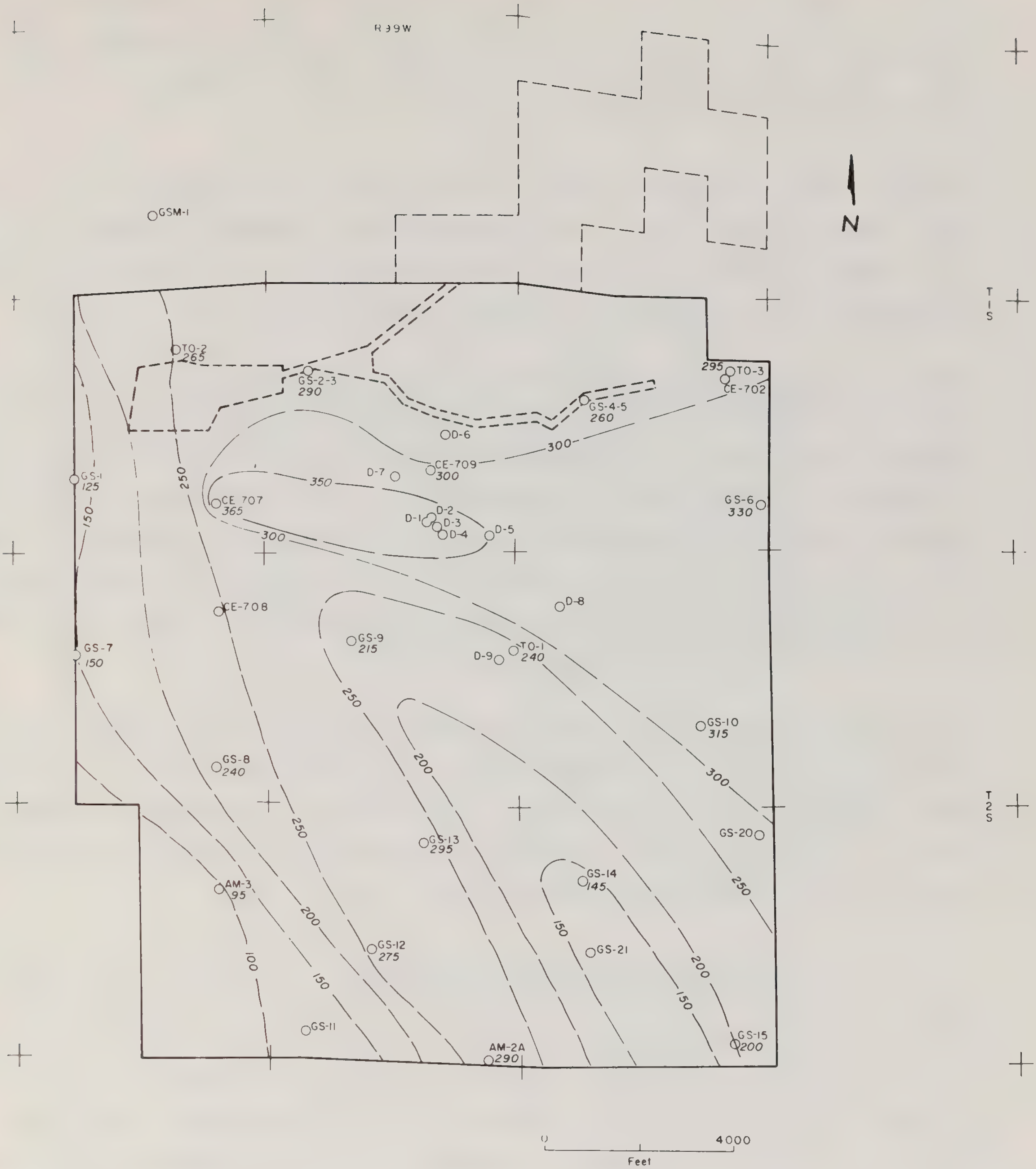



**Figure 2-4-16**
**Isopach of Upper Aquifer**

short-term pump test data for the Upper Aquifer in Tract C-a are contoured on Figures 2-4-17 and 2-4-18. These maps indicate that the transmissivities range from 2,000 to 18,000 GPD per foot. The range of values for the coefficient of storage is from $10^{-5}$ to $10^{-3}$.

GE-Tempo (1980) evaluated aquifer recovery data and suggested a value of about 3,000 GPD per foot. The transmissivities reported by Weeks, et al, (1974) were between 300 and 2,000 GPD per foot in the tract area. The storage coefficient reported in that publication is $10^{-3}$.

Drawdown cones for pump tests performed on the Upper Aquifer are elliptical, which is indicative of a strongly anisotropic aquifer. Anisotropism is apparently the result of geologic structure: fault and joint or fracture orientation. At the level of the Upper Aquifer, some faults appear to act as hydraulic boundaries or barriers to flow. Fractures act as preferential flow paths. The orientation of the major axis of the elliptical drawdown curves produced by baseline pump tests is about N23°W, which is controlled by the major faults and a northwest trending joint set.

The values of transmissivity contoured in Figure 2-4-17 represent mean transmissivities that would be obtained from a pump test. The conversion from these average values to directional values involves multiplying the mean value by 2 to estimate transmissivity in northwesterly direction and by 0.5 to estimate the value along a northeasterly line.

3) Recharge and Leakance Mechanisms - Recharge of the Upper Aquifer occurs by infiltration at its outcrop area west of the tract and to a limited extent by infiltration of water from other aquifers above and below the Upper Aquifer. Pump test results and piezometric levels indicate that the Upper Aquifer is naturally connected to the Lower Aquifer in the northeastern portion of the tract. Analyses of the configuration of the piezometric surface of the Upper Aquifer over a portion of the tract indicate that recharge occurs beneath the ridges on tract. This recharge likely results from the downward leakage of rainfall and snowmelt into the aquifer. Areas of recharge indicated by these analyses are shown in Figure 2-4-19.

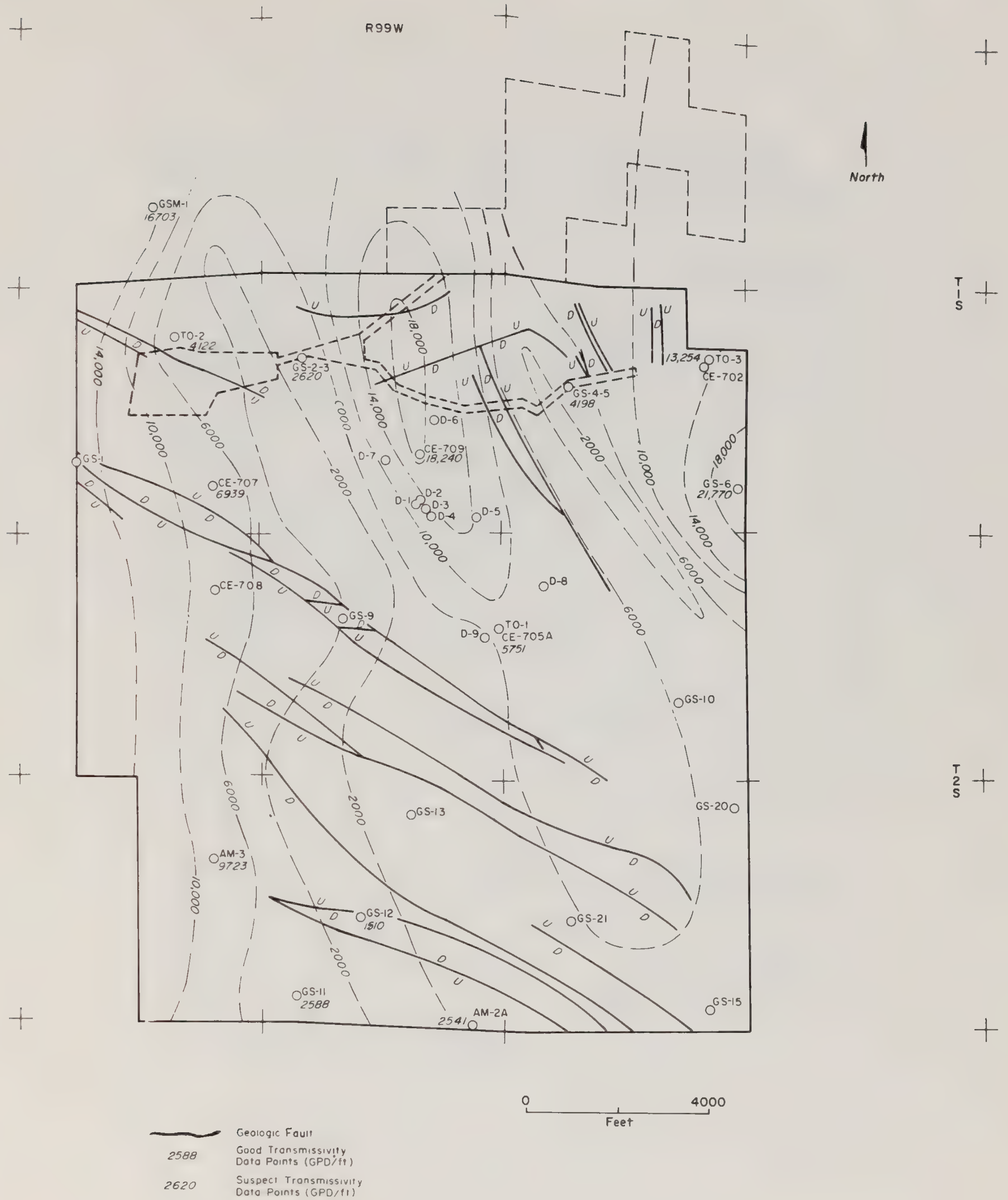



**Figure 2-4-17**
**Upper Aquifer Transmissivity (GPD/ft.)**

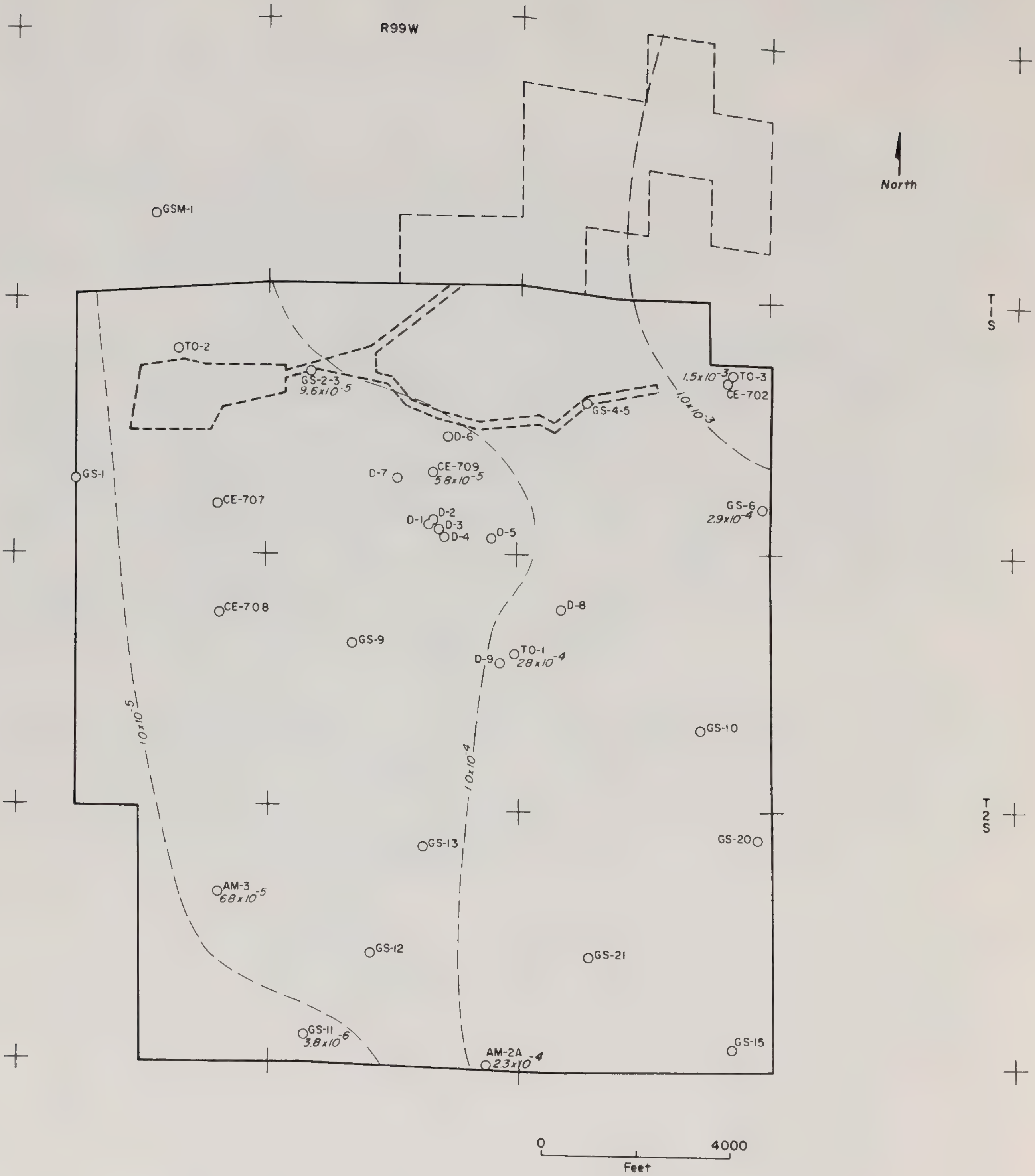



**Figure 2-4-18**
**Upper Aquifer Storage Coefficient**

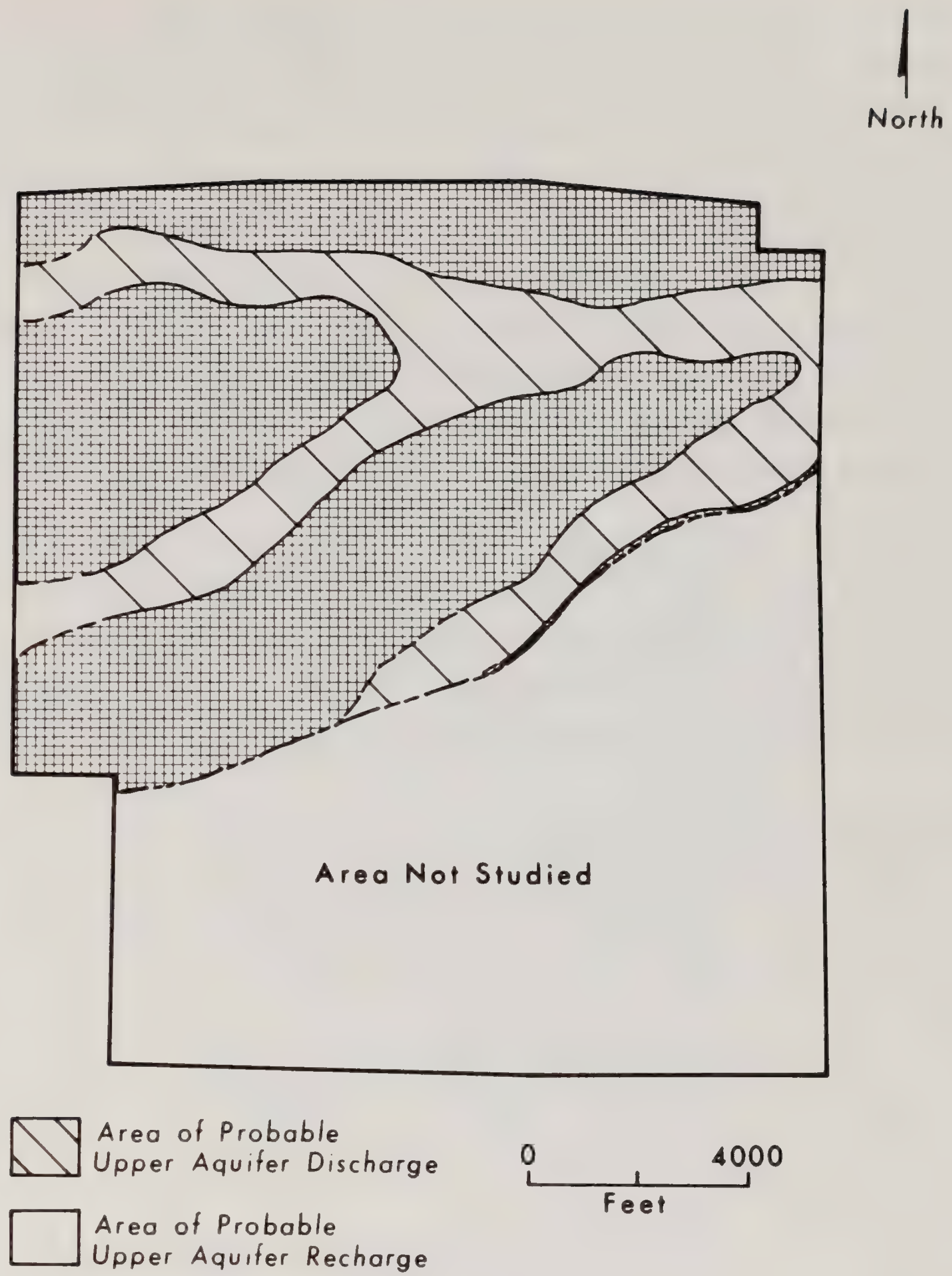



**Figure 2-4-19**
**Upper Aquifer Recharge and Discharge Areas**

Leakage from the Upper to the Lower Aquifer may occur over much of the tract except in the northeast, although the thickness and character of the intervening aquitard indicate that the amount of such leakage likely is small. Leakage also occurs from the Upper Aquifer into the alluvial aquifer material in the valley floors in areas where the piezometric levels of the Upper Aquifer are above the elevation of the base of the alluvial aquifer. If such occurs on site, it appears as alluvial aquifer ground water. Figure 2-4-19 indicates areas where analyses of the shape of the piezometric surface indicate that such discharge may occur. Analyses by RBOSC of area springs indicate that some of the springs result from direct discharge from the Upper Aquifer in areas where piezometric levels are above ground surface.

4) Water Quality - Upper Aquifer water at Tract C-a is generally a very hard, mildly alkaline water with dissolved solids concentrations averaging 900 milligrams per liter. Bicarbonate and sulfate are the dominant anions and sodium is the dominant cation. These three ions account for approximately ninety percent of the total dissolved solids.

Baseline water quality data for the Upper Aqufier is summarized by RBOSP Final Environmental Baseline Study for Tract C-a and Vicinity, 1977, Table 2.83. Post-baseline water quality data are presented in the various Modular Development Phase Monitoring Reports prepared biannually by RBOSC.

5) Baseline Piezometric Levels - Figure 2-4-20 is a presentation of Upper Aquifer piezometric levels in May, 1975, and represents the baseline condition. Regional flow is toward the northeast at a gradient of 100 to 150 feet per mile across Tract C-a.

6) Current Piezometric Levels - Baseline piezometric levels have been modified by mining-related pumping and injection which has occurred at the tract since 1978. Dewatering performed in support of the MIS mine have created a general drawdown of piezometric levels over a portion of the tract. The extent of these lowered piezometric levels are indicated in Figure 2-4-21, which depicts the Upper Aquifer piezometric surface on November 30, 1979. The MIS mine is located at the center of the cone of depression. The spread of the cone in a northeast-southwest direction is inhibited by the

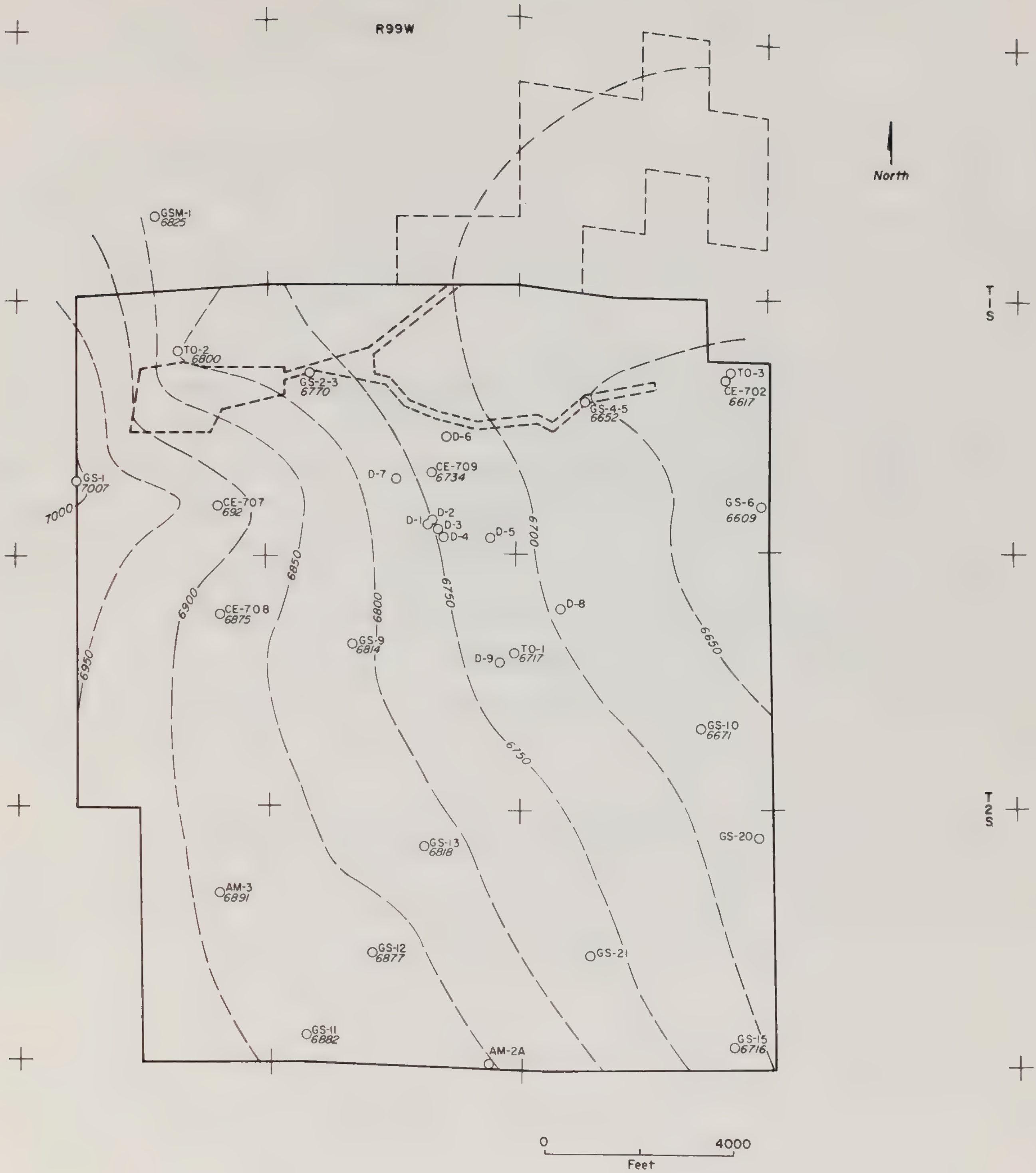



Figure 2-4-20
Upper Aquifer Piezometric Levels - May 15, 1975

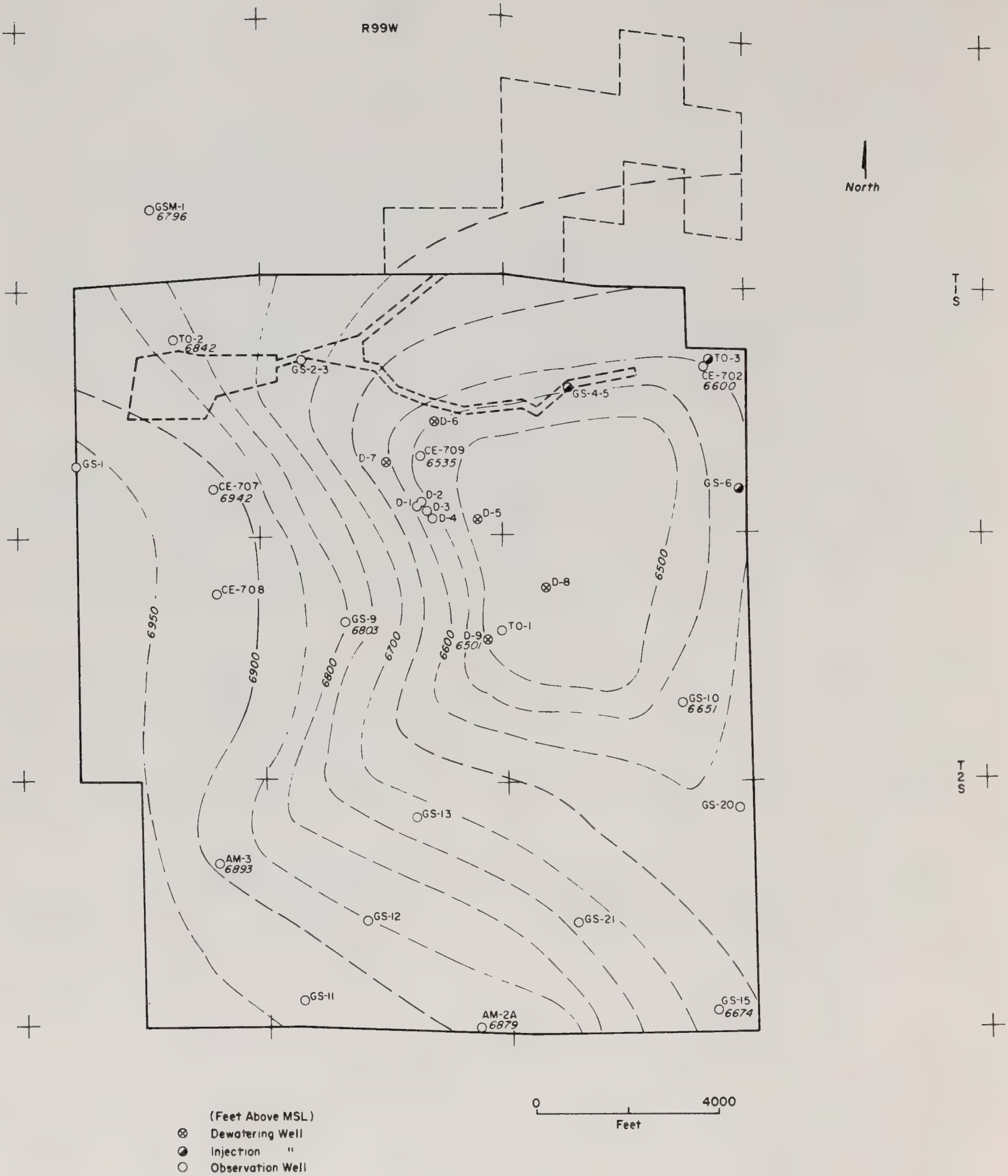



**Figure 2-4-21**
**Upper Aquifer Piezometric Levels - November 30, 1979**

directional character of the Upper Aquifer permeability. Reinjection wells in the southeast and northwest have limited the spread of the cone of depression in these directions.

c. Lower Aquifer - As defined on Tract C-a, the Lower Aquifer is the fractured and vuggy oil shale and marlstone in the "leached zone" of the lower portion of the Parachute Creek Member. The approximate stratigraphic limits of the aquifer are the bottom of the R-4 zone and the top of the underlying Garden Gulch Member.

The aquitard between the Upper and Lower Aquifer is lithologically similar to the aquifers themselves. Its decreased vertical permeability may be attributed to reduced secondary porosity, and increased fracture filling. The aquitard varies somewhat in thickness across the tract in the southwest to over 800 feet in the northeastern corner. The average thickness is about 500 feet. Variation of the aquitard thickness is related to increases and decreases in the thickness of the zones of high secondary porosity in the Upper Aquifer and in variations in the thickness of the connected leached zones in the Lower Aquifer. An isopach of the aquitard is shown in Figure 2-4-22.

1) Aquifer Character - The configuration of the top of the Lower Aquifer is illustrated on Figure 2-4-23. The influence of faulting on the Lower Aquifer is not discernable from pump tests as is the case for the Upper Aquifer. This is attributed to either a decrease in fault displacement with depth, a change in the hydrologic effects of faulting, or both.

The thickness of the Lower Aquifer would be quite variable if isolated zones in the Garden Gulch were included. Otherwise the aquifer would be moderately uniform in thickness varying between 100 and 300 feet.

2) Hydraulic Properties - The fracture porosity and permeability of the Lower Aquifer is enhanced by vugs or cavities which developed as the result of dissolution of soluble saline minerals.

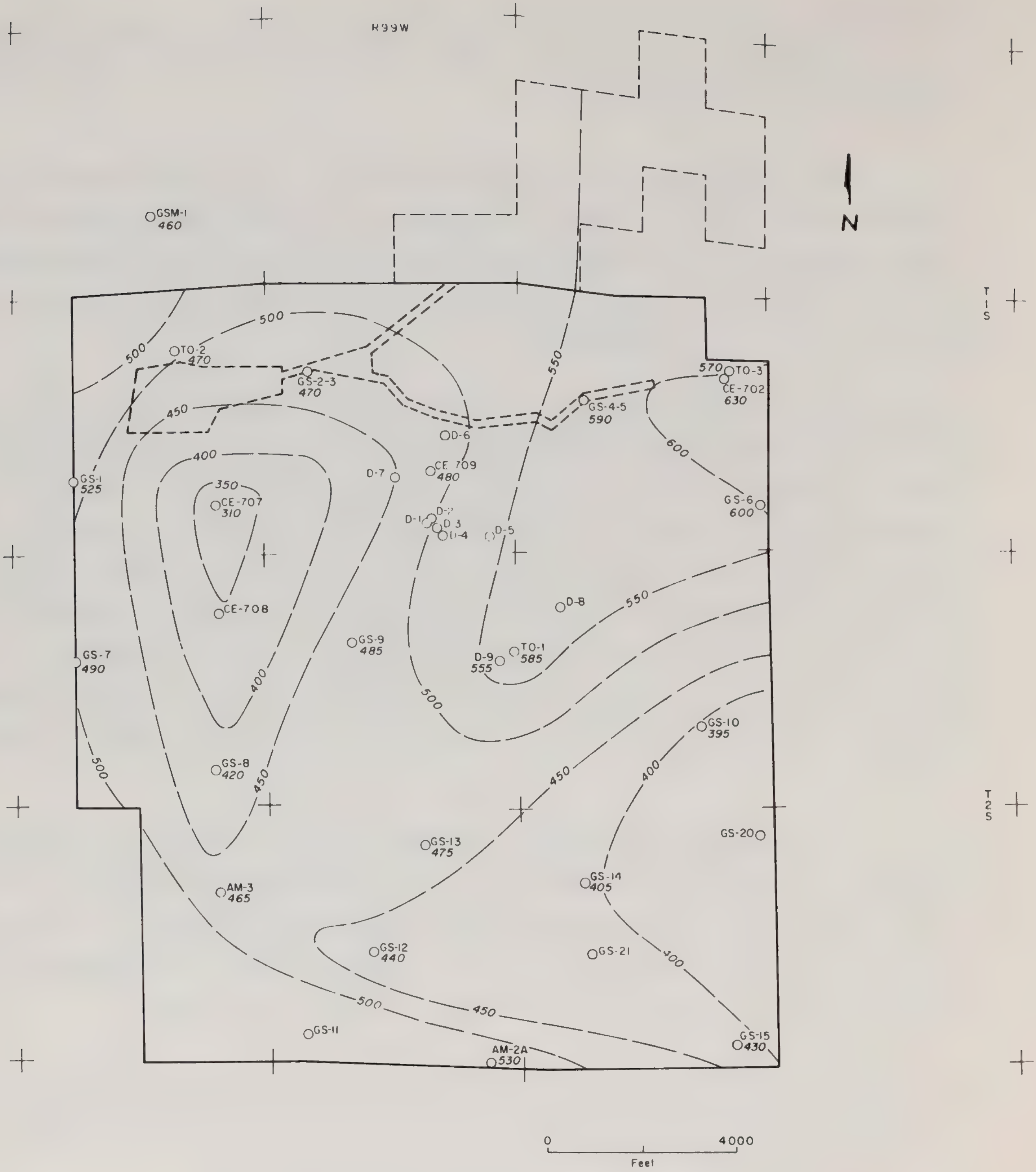



Figure 2-4-22
Isopachof Aquitard

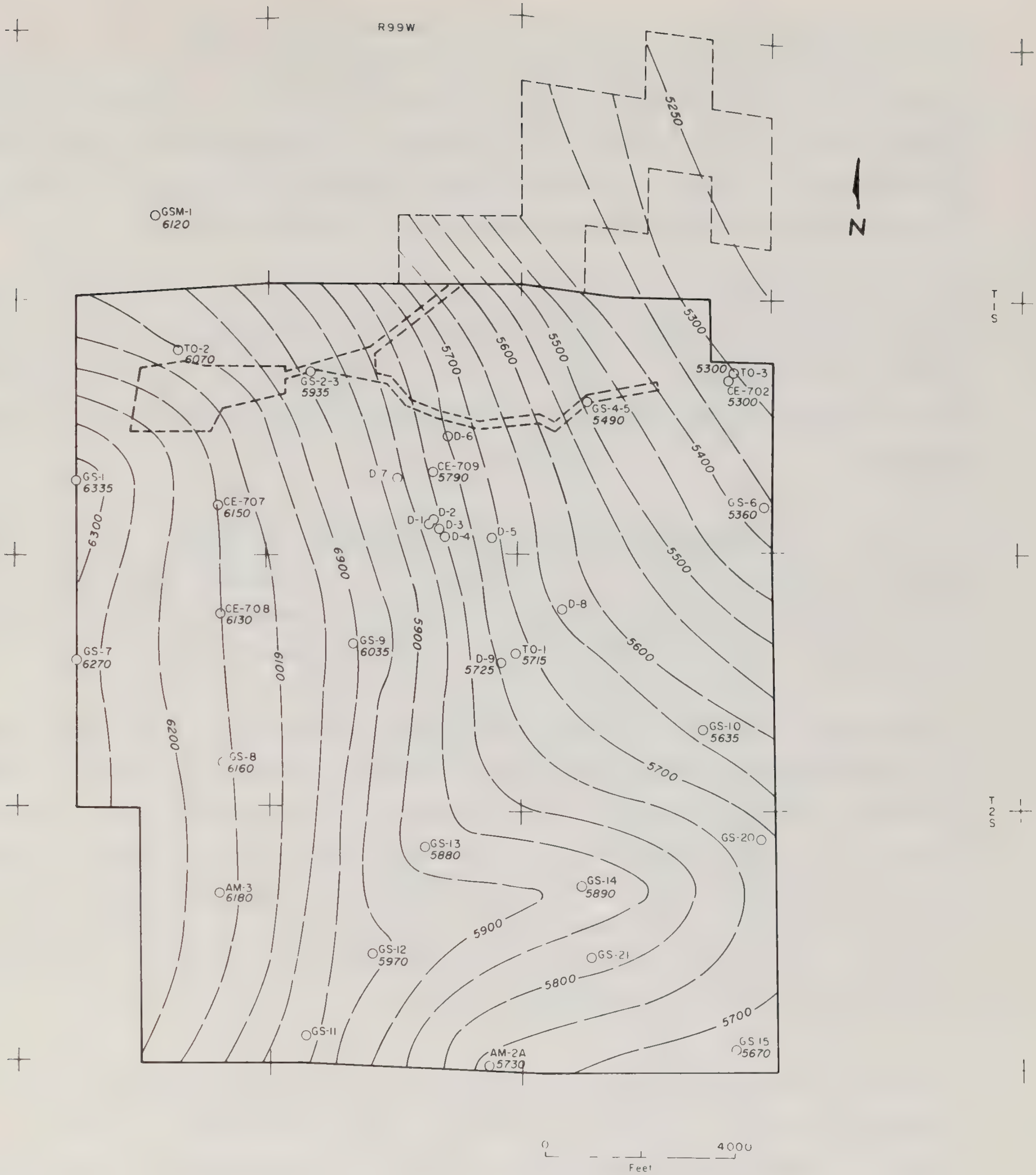



**Figure 2-4-23**
**Top of Lower Aquifer**

Lower Aquifer hydraulic parameters were determined by several short-duration and one long-duration pumping tests. The representative transmissivity value computed from test results is about 7,000 GPD per foot. The average storage coefficient value is $2.0 \times 10^{-4}$. Values of transmissivity and storage coefficient for the Lower Aquifer are illustrated on Figures 2-4-24 and 2-4-25. These contours represent mean values at each location.

Pump test drawdown cones indicate that the Lower Aquifer is slightly anisotropic, but not as markedly as the Upper Aquifer. Transmissivity is greatest along a line trending at N11°W. Faults present at the level of the Lower Aquifer apparently do not act as hydraulic barriers as they do in the Upper Aquifer.

3) <u>Recharge and Leakance Mechanisms</u> - Recharge of the Lower Aquifer occurs primarily by infiltration in its outcrop zone west of the site. Additional recharge probably results from downward migration of Upper Aquifer water through fractures in the intervening aquitard.

No evidence of leakage from the Lower Aquifer within Tract C-a has been found with the exception of the area in the northeast corner of the tract. In that area the relative positions of the piezometric levels of the Lower and Upper Aquifer are reversed from their conditions elsewhere on the tract; the Lower Aquifer piezometric level is a few feet above that of the Upper Aquifer. The result is, under natural conditions, upward migration of Lower Aquifer water through the fractured aquitard into the Upper Aquifer. Presently reinjection to the Upper Aquifer reverses the situation.

Pump test data support the hypothesis of a hydraulic connection existing between the Upper and Lower Aquifers in the northeastern portion of the tract. A significant response was observed in the Upper Aquifer due to Lower Aquifer pump tests at GS-D-18 and GS-D-19. GE-Tempo (1980) has suggested, however, that this response may result from fracturing experiments performed in this area in 1973 by the USGS.

A mechanism may also exist for downward migration of Lower Aquifer waters into still deeper bedrock aquifers; however, no data are available to confirm this leakance mechanism.

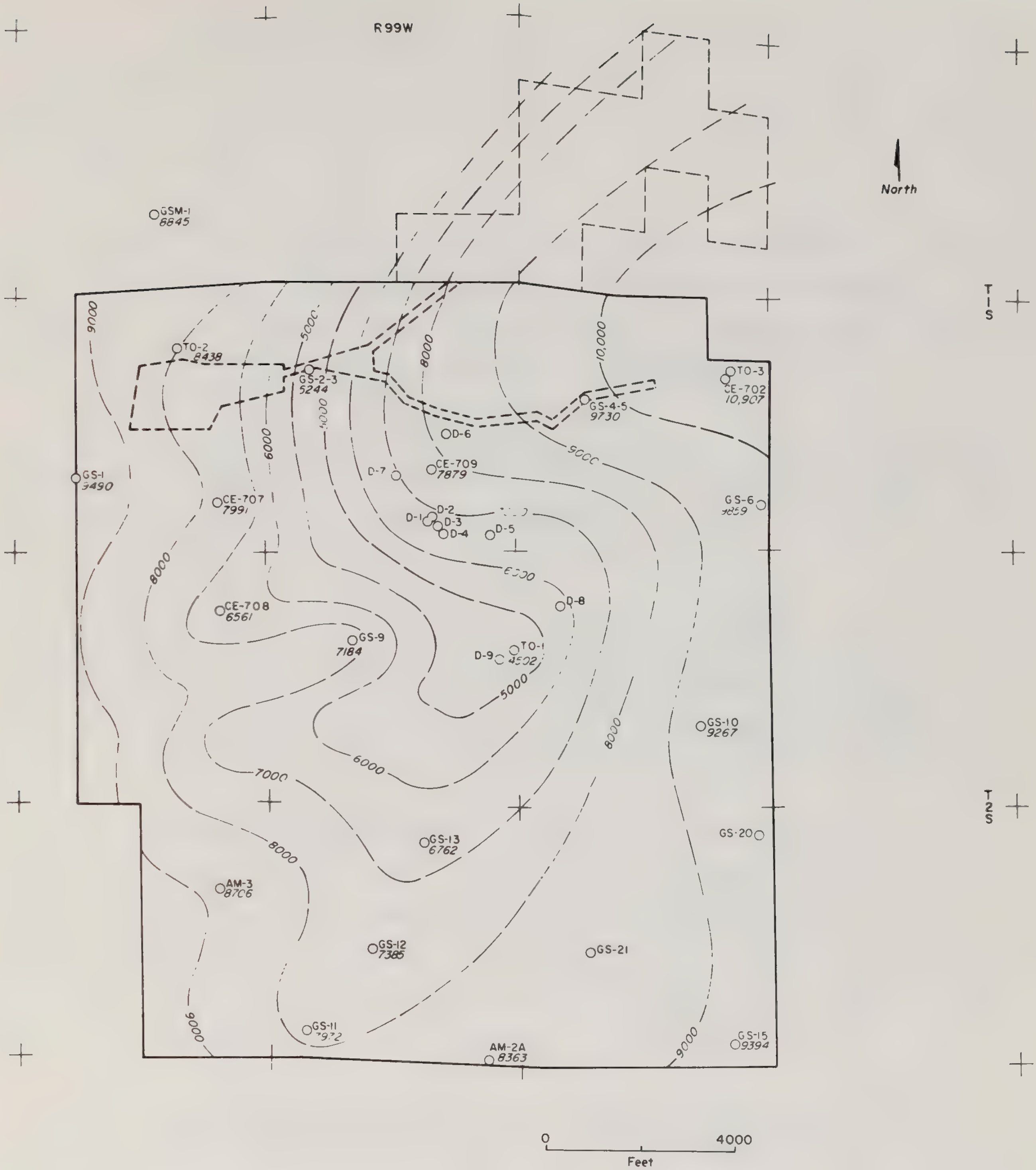



**Figure 2-4-24**
**Lower Aquifer Transmissivity (GPD/ft)**

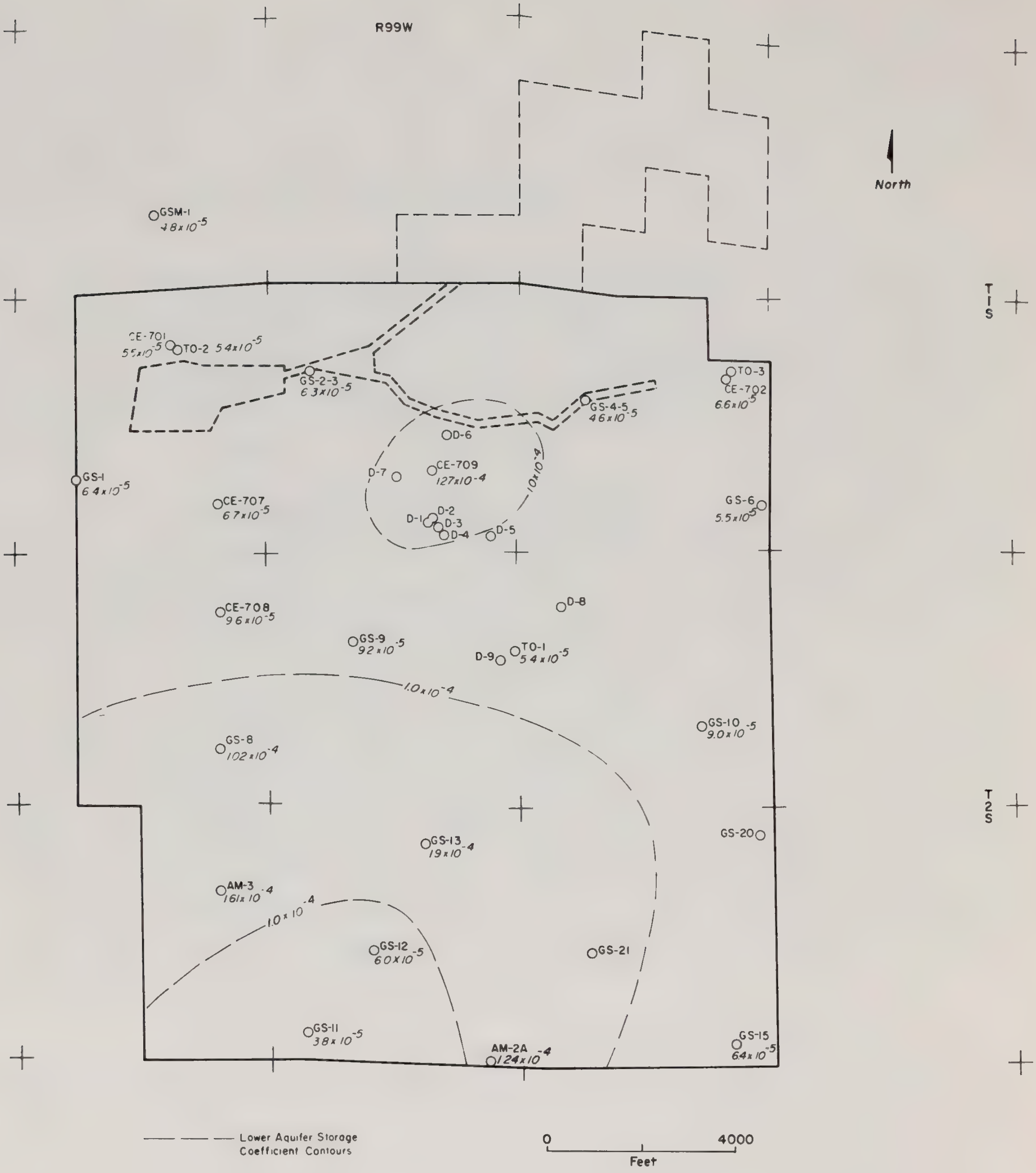



**Figure 2-4-25**
**Lower Aquifer Storage Coefficient**

4) Aquifer Water Quality - Lower Aquifer water at Tract C-a is generally a moderately hard, alkaline water with dissolved solids concentrations averaging 1100 milligrams per liter. Bicarbonate and sodium are the dominant ions in solution and account for seventy-five percent of the total dissolved solids.

Baseline ground water quality for the Lower Aquifer is summarized by RBOSP Final Environmental Baseline Report for Tract C-a and Vicinity, 1977, Table 2.86. Post-baseline water quality data are presented in the various RBOSC prepared Modular Development Phase Monitoring Reports.

5) Baseline Piezometric Levels - Figure 2-4-26 shows Lower Aquifer piezometric levels measured in January, 1975, which represent base line water levels. The piezometric gradient is variable, but generally is toward the east at between 5 and 30 feet per mile.

The Lower Aquifer piezometric surface is significantly different from that of the Upper Aquifer. The flatter gradient in the Lower Aquifer without significantly different transmissivity values indicates that locally ground water movement in the Lower Aquifer is much slower than in the Upper Aquifer.

d. Potential Bedrock Aquifers - Although the Upper and Lower Aquifers of the Parachute Creek are the most important aquifers in the Piceance Basin, ground water does occur in other bedrock aquifers. Principal among these are water-bearing units within the Uinta Formation, the Parachute Creek Member above the Upper Aquifer, and the Douglas Creek Member of the Green River Formation.

1) Uinta Formation - Fractured Uinta Formation sandstones are expected to form local perched aquifers. Where present, perched Uinta aquifers are recharged by infiltration of snowmelt and waters migrating downward into fractured Parachute Creek marlstones or discharge as springs at the contact between the sandstones and marlstones. Uinta piezometric levels are expected to respond directly to seasonal precipitation and the aquifers may be totally drained during dry seasons. Perched Uinta Formation aquifers have not been encountered by drilling on Tract C-a and no identified springs

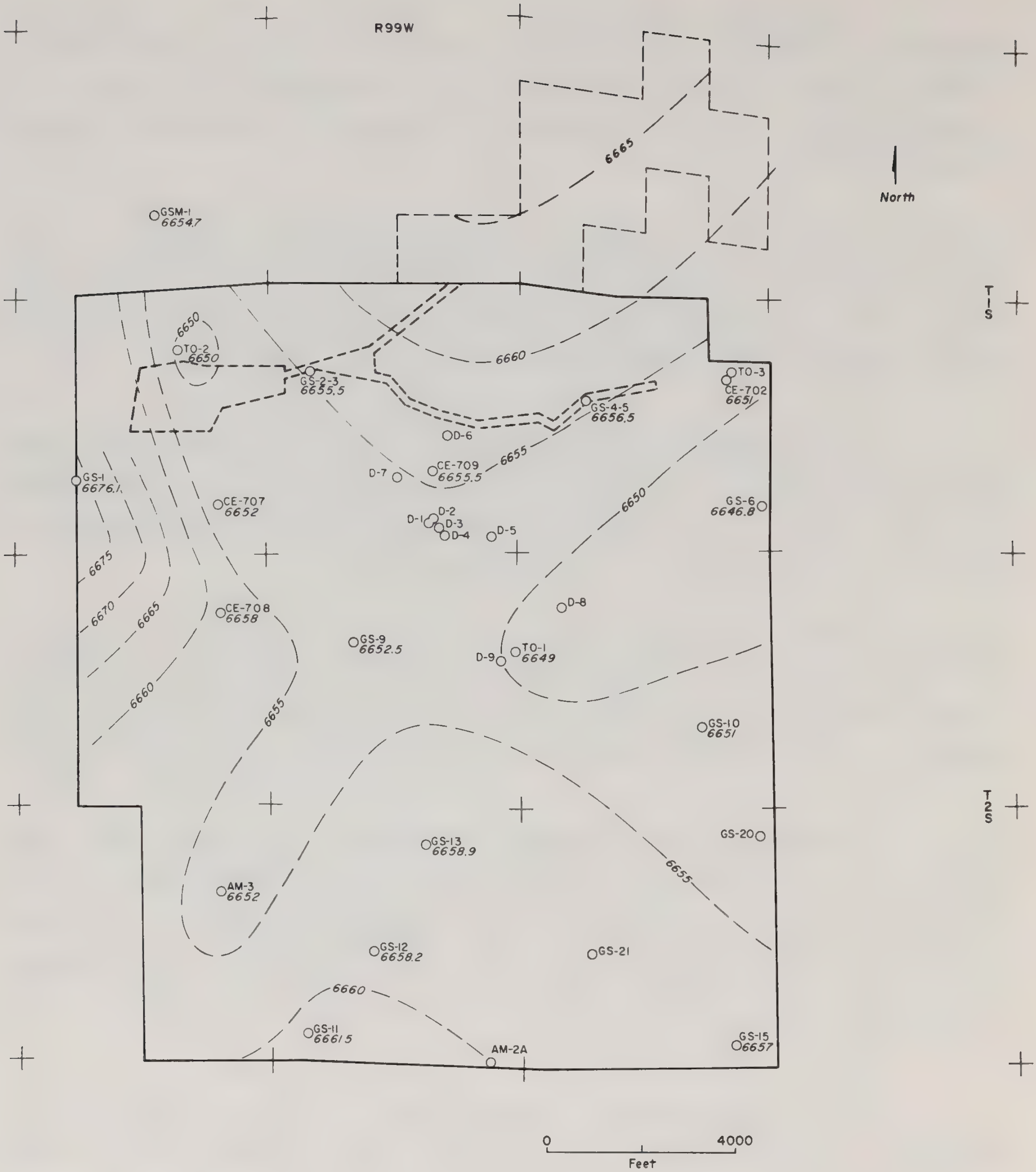



**Figure 2-4-26**
**Lower Aquifer Piezometric Levels - January 11,1975**

or seeps are found in the Uinta Formation. However, the Uinta Formation caps the higher ridges on the tract and seasonal infiltration into the sandstone bedrock is likely.

2) Upper Parachute Creek Aquifers - Fractured oil shales and marlstones within the Parachute Creek Member above the Upper Aquifer are present in the Tract C-a area. One or more aquifers may be present above the Upper Aquifer and isolated from it by tight marlstones or oil shale confining layers. A confined aquifer of this type was apparently identified north of the site in borehole GS-M-6. Water was encountered at that location at a level estimated to be about 200 feet above the top of the A-groove. This water-bearing unit has been identified as a confined aquifer above the Upper Aquifer. A program to further define this unit and its significance is currently underway.

3) Douglas Creek Member - The Douglas Creek Member is composed of sandstone, shale, and limestone and lies at an estimated depth of 2,500 feet beneath Tract C-a. This confined aquifer is considered to have low primary porosity, low fracture density and resultant low permeability. No direct hydrologic information has been obtained for the Douglas Creek Member in the Tract C-a area.

## 4.2 SURFACE MINE HYDROLOGIC CHARACTERIZATION

The ground water hydrologic system in the surface mine area includes three aquifer systems; two bedrock aquifers and an alluvial aquifer. The two bedrock aquifers in the mine area of potential significance to the surface mine are the Upper Aquifer and the Lower Aquifer. Both of these aquifers occur within the Parachute Creek Member of the Green River Formation. The Upper Aquifer is associated with the Mahogany zone and the Lower Aquifer with a leached zone in the lower portion of the Parachute Creek Member. The Lower Aquifer is separated from the Upper Aquifer by an aquitard approximately 500 feet thick. The hydraulic effectiveness of this aquitard has been demonstrated by previous mining activities on the tract. For this reason it is expected that the proposed mine will not significantly affect nor be affected by the Lower Aquifer. Therefore, the only bedrock aquifer in the mine area of significance to the proposed mining activities is the Upper Aquifer.

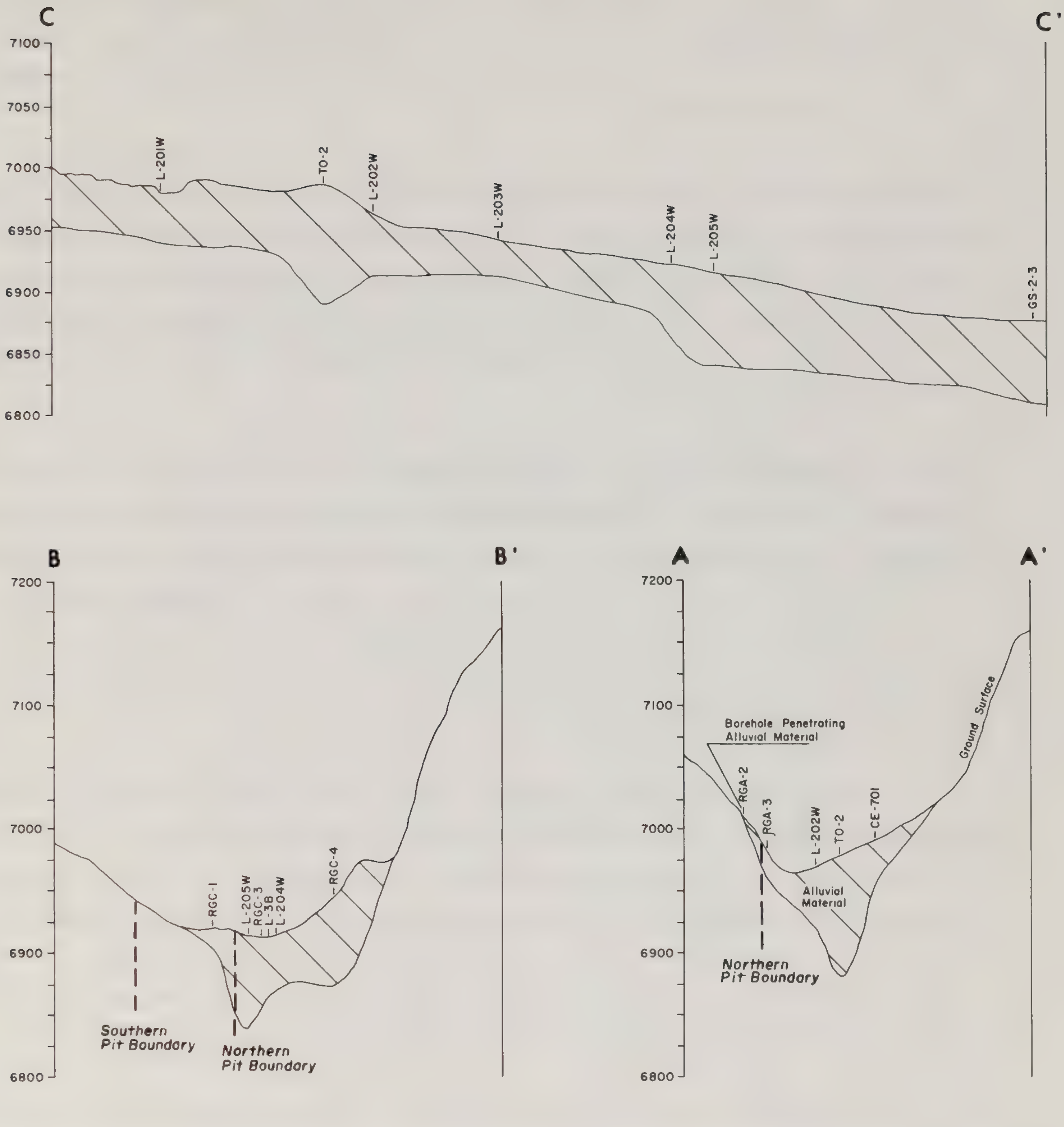
The surface water system in the mine area consists of drainage to Dry Fork and smaller tributaries which may be affected by the proposed mining operation. Information gathered from published regional sources and on-site studies were used to characterize this hydrologic system.

A. Alluvial Aquifers - Within the mine area of the Lurgi Demonstration Project, alluvium is present in the two major drainageways, Dry Fork and East Gulch but water is generally only present in East Gulch. The materials described as the alluvial aquifer include alluvium, colluvium, and to a limited extent, residual soils. The alluvium and colluvium are derived from materials from the same sources; Uinta formation sandstones, siltstones and marlstones and upper Parachute Creek Member marlstones, oil shale, and siltstones. Alluvial materials occupy the bottom of the drainageways and colluvial materials occupy the flanks of drainageways as fans or aprons at the base of the adjoining hills.

The alluvial aquifer in the mine area is composed of gravel-, cobble-, and boulder-sized fragments of marlstone, oil shale, sandstone, and siltstone in a brown silty sand or dark brown silty clay/clayey silt matrix. The moisture content of the alluvial materials increases with depth and varies seasonally.

1. Aquifer Thickness - The alluvium occupies an area within Dry Fork which is between 400 and 800 feet wide. The thickness of these unconsolidated materials is between 0 and 100 feet, averaging about 50 feet. Figure 2-4-12 illustrates the areal extent and thickness of the alluvium in the pit area. Figure 2-4-27 shows typical valley profiles. The alluvium is expected to be unsaturated except, perhaps, during the snowmelt period when high stream flows may induce water storage in the alluvial material.

2. Aquifer Properties - Hydrologic testing has not been performed on the alluvial aquifer within Tract C-a. Basin-wide testing indicates that the hydraulic conductivity of the aquifer is high and is reflected in transmissivities ranging from 20,000 to 150,000 GPD per foot. Storage coefficients are estimated to be about $2 \times 10^{-1}$. Hydrologic testing to define the hydraulic properties of the alluvial aquifer in the mine area is currently underway.




Profile Sections Located in Figure 2-4-12

**Figure 2-4-27**
**Alluvial Aquifer Profiles**

3. Recharge and Leakance Mechanisms - Within the tract, recharge to alluvial aquifers is attributed to infiltration of snowmelt runoff and infiltration of spring flow discharging from bedrock aquifers. No springs have been identified in Dry Fork or its tributaries upstream of its confluence with Corral Gulch.

Borehole TO-2 has been operated intermittently as an injection well since 1978. Water from MIS dewatering is injected into an open hole interval between the depths of 165 and 425 feet. Induced recharge to the alluvial aquifer from this injection well has not occurred because monitoring well GS-L-202W does not contain water above the top of bedrock at its location about 200 feet south of TO-2.

4. Piezometric Levels - Alluvial water level monitoring on the tract was initiated in 1975 and included one monitoring well in the mine area, GS-S-6. This well has remained dry throughout the monitoring period. Six additional monitoring wells were drilled in the mine vicinity in November, 1980. Water has not been observed in these wells. However, monitoring has not occurred at these wells during spring snowmelt, when the probability of saturated alluvium is the greatest.

5. Effects of Mining on Aquifer - The north edge of the mine will encroach upon the southern edge of the alluvium in Dry Fork. The thickness of the alluvium in Dry Fork varies from 0 to 100 feet. The excavation for the proposed surface mine and access ramp will intersect between 0 and 50 feet of alluvial material. The maximum thickness of alluvium is intersected by the mine access ramp in the area where the ramp crosses East Gulch. This material will be removed during ramp excavation.

Wells completed in the alluvium in the mine area indicate that the alluvium is unsaturated; however, during periods of high infiltration and surface flow in the channel of Dry Fork, a saturated zone may be created temporarily in the alluvium. Because the maximum thickness of the alluvium is not penetrated by the mine, and because the saturated condition of the alluvium is transient, seepage from the alluvium into the pit wlll be nominal if it occurs at all.

B. Upper Aquifer - In the mine area the Upper Aquifer consists of two major zones: one is associated with the A-groove and is close to water table pressure conditions; the other is associated with the B-groove and is under a confining head of about 300 feet.

1. Aquifer Thickness - The thickness of the Upper Aquifer in the mine area ranges from 100 to 300 feet, averaging about 200 feet. Figure 2-4-16 illustrates Upper Aquifer thickness. In the mine area, the depth below ground surface to the top of the aquifer ranges from 100 feet in Dry Fork to 250 feet on Sagebrush Hill. The configuration of the stratigraphic top of the Upper Aquifer is illustrated on Figure 2-4-15.

2. Hydraulic Properties - The Upper Aquifer is composed of fractured oil shales and marlstones in which primary porosity and permeability is small in comparison to secondary porosity and permeability. Secondary porosity is primarily attributed to fractures and to a lesser extent to the dissolution of soluble minerals.

Figures 2-4-17 and 2-4-18 illustrate values of transmissivity and storage coefficient which have been determined from Upper Aquifer pump test results. These data indicate the average value for transmissivity in the mine area is about 6,000 GPD per foot and the average storage coefficient is about $5 \times 10^{-5}$. In order to account for the anisotropy of transmissivity observed in pump tests, it is necessary to multiply the mean transmissivity by 2 to estimate transmissivity in the northwesterly direction and by 0.5 to estimate the value in a northeasterly direction.

3. Leakance and Recharge Mechanisms - The Upper Aquifer is recharged along its outcrop zone west of the mine area on the flanks of Cathedral Bluffs. Additional recharge is attributed to downward migration of water through fractures. Recharge of this type apparently occurs beneath areas of higher topography in the site area.

Leakage from the aquifer in the mine area may occur as downward migration along fractures through the underlying aquitard into the Lower Aquifer. Upward leakage or discharge at the surface as springs or seeps does occur within the tract; however, there are no such discharge zones in the pit area.

Upward leakage into unspecified bedrock aquifers above the Upper Aquifer may occur within the tract boundaries. Specific instances of such leakage have not been identified in the mine area.

4. Piezometric Levels - Figures 2-4-20 and 2-4-21 illustrate piezometric levels within the Upper Aquifer at different times. Figure 2-4-20 represents baseline piezometric levels prior to any significant modification caused by site activities. Figure 2-4-21 illustrates the effect of MIS dewatering and reinjection.

5. Effects of Mining on the Aquifer - Mining will progress in the dry to about elevation 6,900. Below this elevation, water from the Upper Aquifer will be handled within the excavation. Dewatering will be accomplished by wells, ditches and sumps in order to allow unencumbered excavation and haulage. Depressuring of the B-groove will be initiated by water supply wells to be located near the north wall of the pit. Any additional depressuring required would be handled by wells on inactive benches as the B-groove is uncovered. Water inflow to the mine dewatering system will increase as the excavation progresses. The maximum flow to the excavation will occur upon completion of mining when excavation has removed the Mahogany zone. The dewatering system for the mine will be required to handle the increasing flow which will occur during overburden removal, and a nearly steady state flow from the A-groove and B-groove associated water-bearing zones which will occur during and after removal of the Mahogany zone. The total steady state inflow to the mine area is estimated to be about 1,600 GPM, with about 600 GPM removed by wells and about 1,000 GPM flowing into the mine. The mine sump system and ancillary structures will be sufficient to handle a continuing flow of 3,000 GPM. Aquifer testing will be conducted in the proposed mine system, prior to mining, to verify the estimate.

Full dewatering from the mine is expected to occur over a period of about 46 months. During this time, the removed water will be utilized to fulfill various project water requirements or disposed. The primary mechanism for disposal is anticipated to be through injection wells although disposal may occasionally occur by discharge to Dry Fork. Analyses were performed to model the dewatering operations at the site and to determine the effects artificial recharge may have on dewatering. These analyses involved characterizing the properties of the Upper Aquifer, calibrating a mathematical model to the estimated pumpage from the MIS facility, and subjecting the calibrated model to stresses from continued MIS pumpage, the mine pumpage and artificial recharge. The results of these analyses are presented as Figures 2-4-28 through 2-4-30.

Figure 2-4-28 represents the effects of pumpage and artificial recharge from operations at the MIS facility and pumpage of the Lurgi Demonstration Project water supply wells. These figures assume operations at the MIS facility over the next one and one half years will be similar to those which have occurred prior to 1980 and that the water supply wells will have been pumped at a rate of 195 GPM for 18 months. It can be seen that drawdown in the Upper Aquifer will exceed 200 feet at the MIS facility; however, the southern and eastern extent of significant drawdown is limited by natural geologic features and by existing injection wells. The dewatering of the MIS system and pumpage of the Lurgi Demonstration Project water supply wells near the northern tract border cause are expected to ground water drawdown to occur about 10 miles northward.

Figure 2-4-29 represents the tract area drawdown at the end of the operational phase of this Lurgi Demonstration Project, and four years after the abandonment of the MIS facility. It can be seen that the drawdown is still expected to exceed 200 feet, but the center of the drawdown will have shifted from the MIS facility to the Lurgi Demonstration Project surface mine. Piezometric levels at the MIS facilities are projected to have recovered to within 50 feet of the original baseline levels. The extent of drawdown to the north of the site is projected not to be significantly different than that of the previous scenario.

Figure 2-4-30 represents recovery conditions of the Upper Aquifer piezometric levels three years after the end of the Lurgi processing and two years after the cessation of any Upper Aquifer dewatering. At this time it is projected that piezometric levels in the disturbed area will have returned to within 40 feet or less of the baseline conditions. The extent of the cone of depression, however, is projected to be very similar to that at the end of the Lurgi operation, and is not significantly reduced.

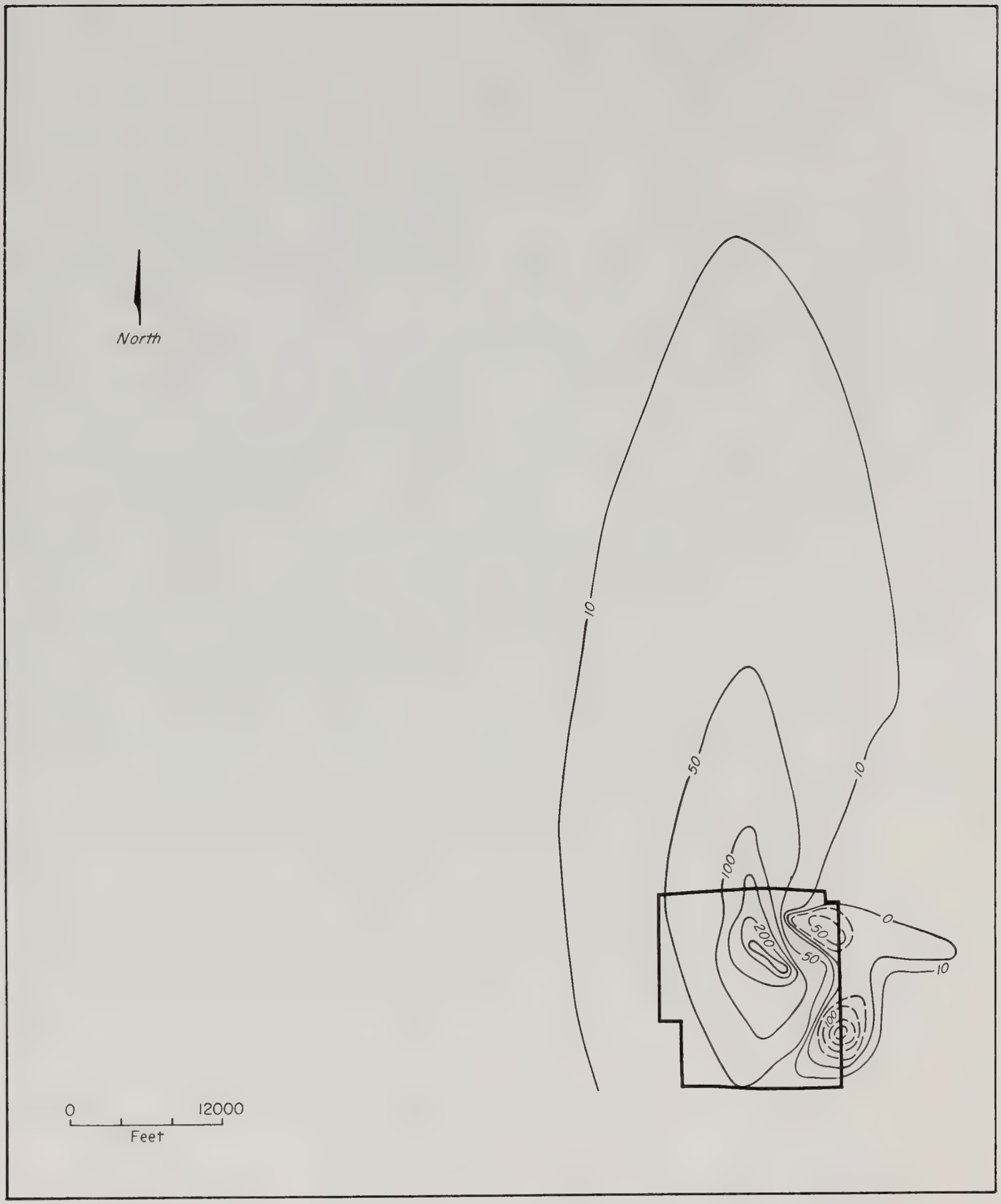



Figure 2-4-28
Estimated Upper Aquifer Drawdown - Inception of Mine Dewatering

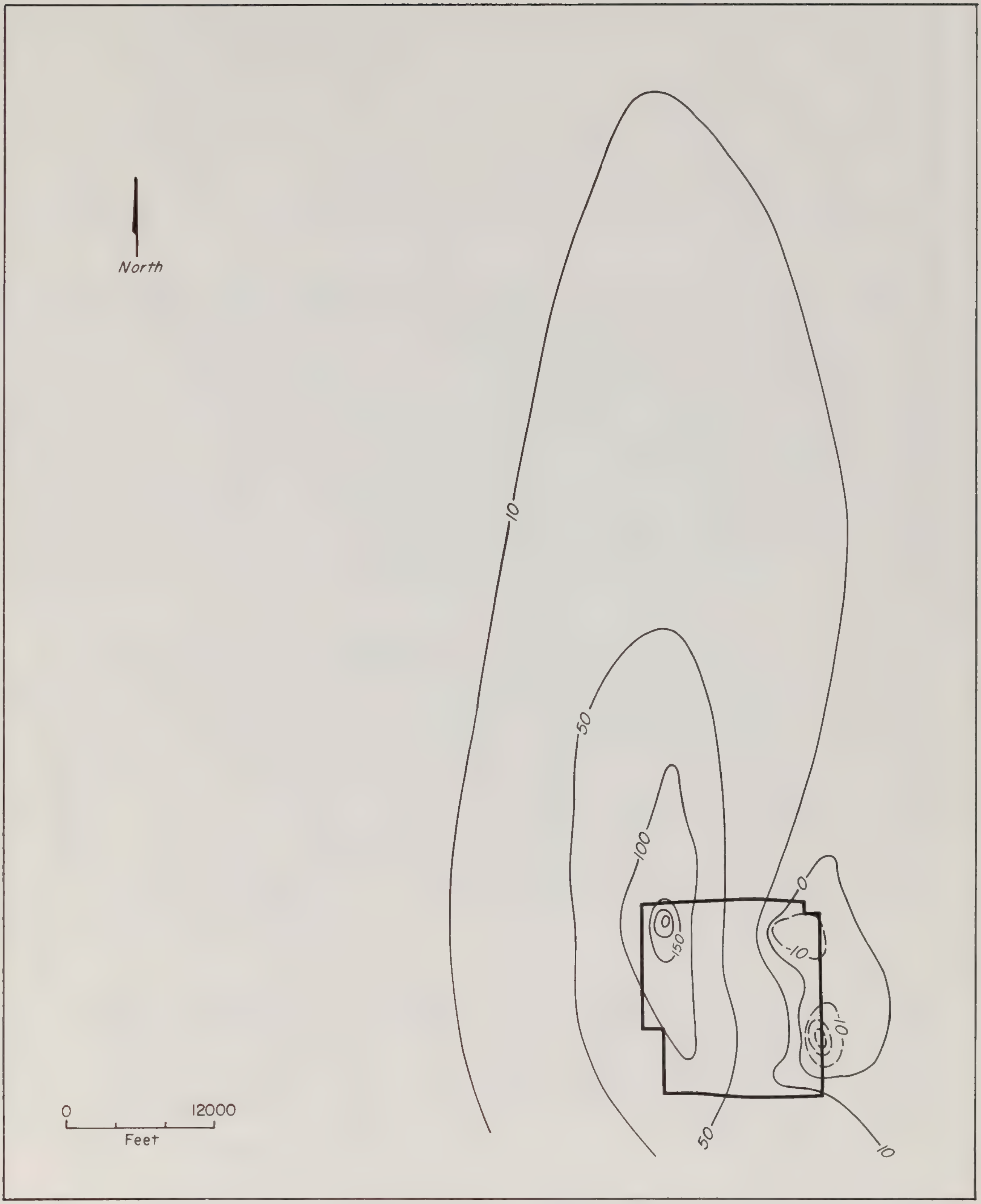



Figure 2-4-29
Estimated Upper Aquifer Drawdown - End of Demonstration Operation

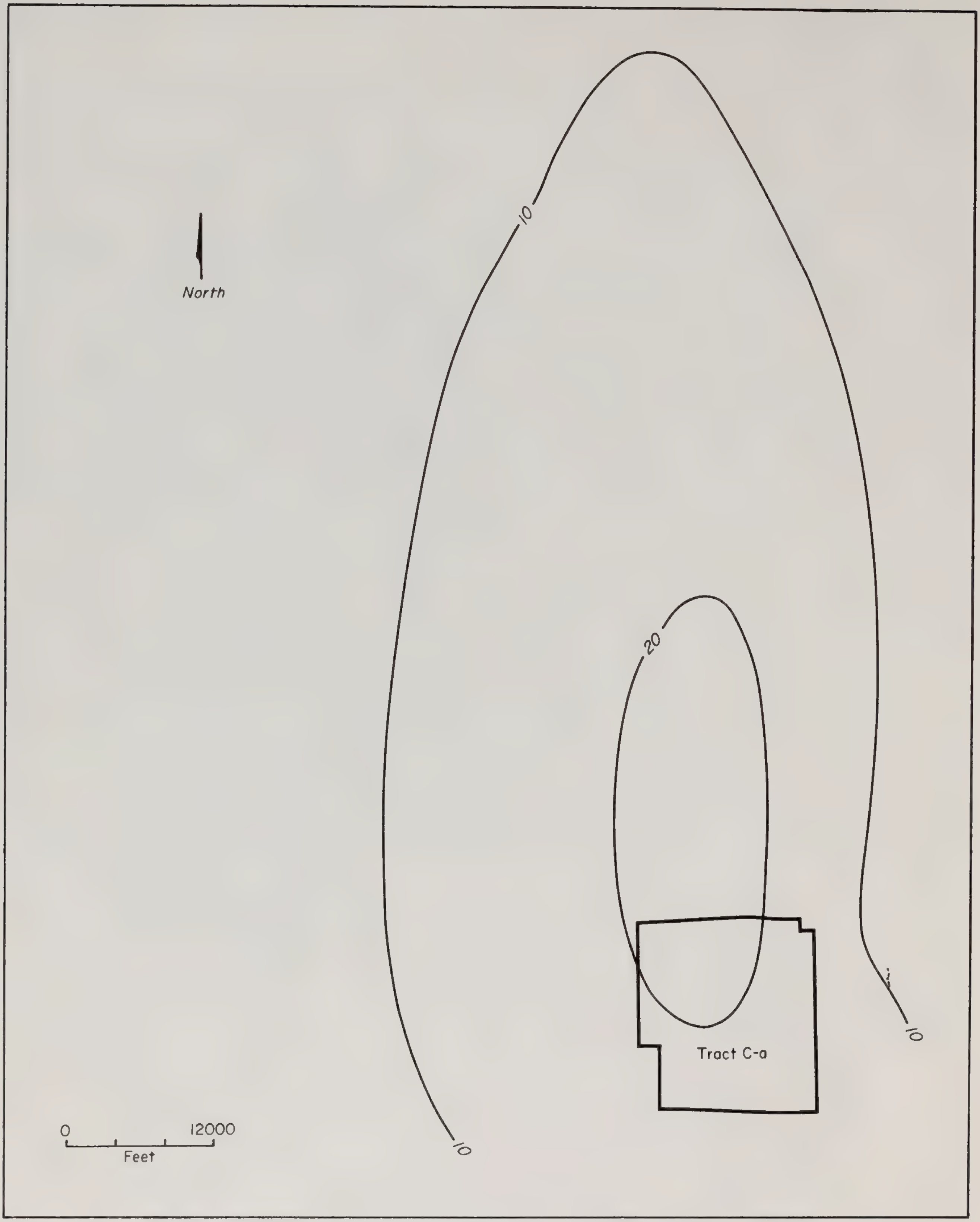



**Figure 2-4-30**
**Estimated Upper Aquifer Drawdown - Three Years of Aquifer Recovery**

Mine closure operations will be designed to allow unencumbered operation in the dry. Therefore, a system of wells, ditches and sumps will be designed to handle precipitation and ground water inflow. The mine will be backfilled to elevations above 6,900 msl with overburden which was removed from the mine in order to re-establish the aquifer condition. Upon completion of backfilling, water will no longer be removed from the mine sump system, and the water supply wells will serve miscellaneous water needs during site reclamation.

C. Surface Water - The surface mine will be located on the hillside south of Dry Fork, an intermittent eastward flowing stream, in the northwestern corner of Tract C-a, and runs roughly parallel to the stream for a distance of about 3,000 feet. The west edge of the mine is about 1,400 feet from the west boundary of Tract C-a (see Figure 1-1-5). The construction of the mine and surrounding facilities will significantly affect the natural local surface hydrologic conditions. Hydrologic conditions that are unique to the immediate area of the mine and which will be affected by the proposed operations are discussed in the following paragraphs.

1. Natural Hydrologic Conditions - The drainage area of Dry Fork at the downstream extent of the proposed mine is 2,500 acres. This basin is characterized as very steep, sparsely vegetated rangeland. The channel of Dry Fork is steep and fairly narrow. Because of the character of the natural soil and vegetation, very high rainfall losses due to infiltration and evapotranspiration occur in the basin. These losses, in conjunction with the fairly low rainfall volumes characteristic of the area, yield relatively small flood flows even for extreme events.

2. Effects of Proposed Construction - The construction of the surface mine and ancillary facilities will create changes in the natural hydrologic regime. Runoff from undisturbed areas will require diversion, and runoff from disturbed areas will require settlement to reduce suspended sediment loads before discharge into Dry Fork.

The modified drainage basin can be conveniently divided into three areas: the Dry Fork sub-basin upstream of the west boundary of Tract C-a, the drainage area north of Dry Fork along the length of the pit, and the drainage area that discharges into Dry Fork from the south.

The Dry Fork sub-basin to the west of Tract C-a covers 1,862 acres and will undergo no modifications. Therefore, the hydrologic response of this basin will not change. At the tract boundary, the peak flow rate from the 100-year, 24-hour storm is estimated at 374 cfs. Downstream of this point, the channel will be modified from its present alignment to provide increased channel capacity in the reach along the mine facilities.

The area that drains into Dry Fork from the north is about 315 acres in extent. Of this area, about 10 acres will be covered by topsoil stockpiles, ponds and lagoons, and haul roads. The runoff from these disturbed areas will be directed to settling ponds before being released to Dry Fork. Minimal undisturbed areas will also drain into settling ponds, however most natural areas will drain directly into Dry Fork, primarily in natural drainage channels which will not be disturbed.

The total area that drains into Dry Fork from the south is approximately 325 acres. The proposed surface mine lies in this area, therefore, it is in this sub-basin that the natural physiography will be most altered. The final surface mine will cover 36 acres. Rainwater inflow to the mine will be removed along with the ground water inflow and discharged into a holding pond system. The disposition of this water is described in Section 7, Chapter 6.2 of this document.

Another significant feature in this southern area is the stockpile-settling pond system. The East Gulch overburden fill will have a volume of about $2.0 \times 10^6$ bulk cubic yards and will cover an area of about 58 acres. An eight acre topsoil stockpile will be located adjacent to the overburden stockpile. Collection ditches will be constructed around both stockpiles and runoff will flow in these ditches to a settling pond located near the southern boundary of the mine. The area draining to this pond will be 142 acres. Storm runoff will be settled in this pond and then discharged to a diversion ditch that collects the settling pond flow as well as natural runoff from an additional 39 acres and carries it downstream from the mine and discharges into Dry Fork. The remaining 106 acres drains unimpeded into Dry Fork.

Although land use changes near the mine area will tend to increase surface runoff, peak flow rates in Dry Fork will be slightly lower as a result of the presence of the surface mine and nearby facilities. This is a result of the flood peak attenuation provided by the various settling ponds which in aggregate provide temporary impoundment of runoff from about 200 acres. The presence of these impoundments, in conjunction with the channel improvements planned, will cause flood elevations to be lower than under natural conditions.

## 5.1 PHYSICAL PROPERTIES OF ROCK

An extensive, comprehensive rock mechanics program was initiated during the exploration phase of this project to determine the rock mechanics parameters essential for mine design. The physical properties of the rock as well as structural information including faults and joints were used for the slope stability analysis.

A. Rock Strength Parameters - The rock strength parameters used for the study were determined primarily by laboratory tests of core from Tract C-a. The following rock properties, considered important for open pit design, were obtained from testing of the cores:

- Uniaxial compressive strength
- Angle of internal friction - intact rock
- Cohesion - intact rock
- Specific gravity
- Shear strength - fracture surface

Following is a discussion of the various individual rock strength parameters utilized during the Lurgi demonstration pit studies. Results of 139 uniaxial and triaxial compression tests on intact rock are presented in Table 2-5-1.

Table 2-5-1

SUMMARIZED RESULTS OF UNIAXIAL AND TRIAXIAL COMPRESSION TESTS FOR THE OVERBURDEN AND MAHOGANY ZONES ON TRACT C-a

| Zone | Number of Tests | Specific Gravity Max | Mean | Min | $S_o$(psi) | Ø (deg.) | $C_o$(psi) |
|---|---|---|---|---|---|---|---|
| OB | 90 | 2.37 | 2.14 | 1.81 | 3,700 | 33 | 13,890 |
| MZ | 49 | 2.48 | 2.15 | 1.71 | 3,300 | 41 | 14,080 |

These test data have been grouped by zones (overburden and Mahogany) and Figures 2-5-1 and 2-5-2 represent an attempt to fit a Coulomb zone. The line shown on each of these figures with its equation is a regression line of maximum and minimum principle stresses. In Table 2-5-1, the number of test results for the overburden and Mahogany zone, the maximum, mean, and minimum specimen densities of the samples tested, the intrinsic cohesion "$S_o$", the angle of internal friction "$\phi$", and the unconfined compressive strength "$C_o$" are given according to this criterion.

Available direct shear data from tests on rock samples with fractures and joints are summarized in Table 2-5-2.

1. Unconfined Compressive Strength - The average values of unconfined compressive strength for the overburden and Mahogany zones throughout Tract C-a are 13,890 psi and 14,000 psi respectively. This is an average derived from both uniaxial and triaxial tests on Tract C-a core samples.

2. Angle of Internal Friction - Intact Rock - A total of 71 triaxial tests were performed to give reliable values for the angle of internal friction for intact rock. The average values for the overburden and Mahogany zones are 33 degrees and 41 degrees respectively.

3. Cohesion - Intact Rock - Average values of intact rock cohesion for the overburden and Mahogany zones were derived from the triaxial tests and are 3,700 psi and 3,300 psi respectively.

4. Specific Gravity - Specific gravity determinations were conducted on all samples. The mean specific gravity for the overburden is 2.14, while the mean specific gravity for the Mahogany zone is 2.15.

5. Shear Strength - Fracture Surfaces - Direct shear tests were conducted on core samples from zones R-6, R-5, L-3, R-3 and L-2. The tests from zones R-6, L-3 and R-3 were conducted with the fracture surfaces oriented parallel to the stratification. One test from zone R-5 was conducted with the fracture surface oriented 60 degrees to stratification while three

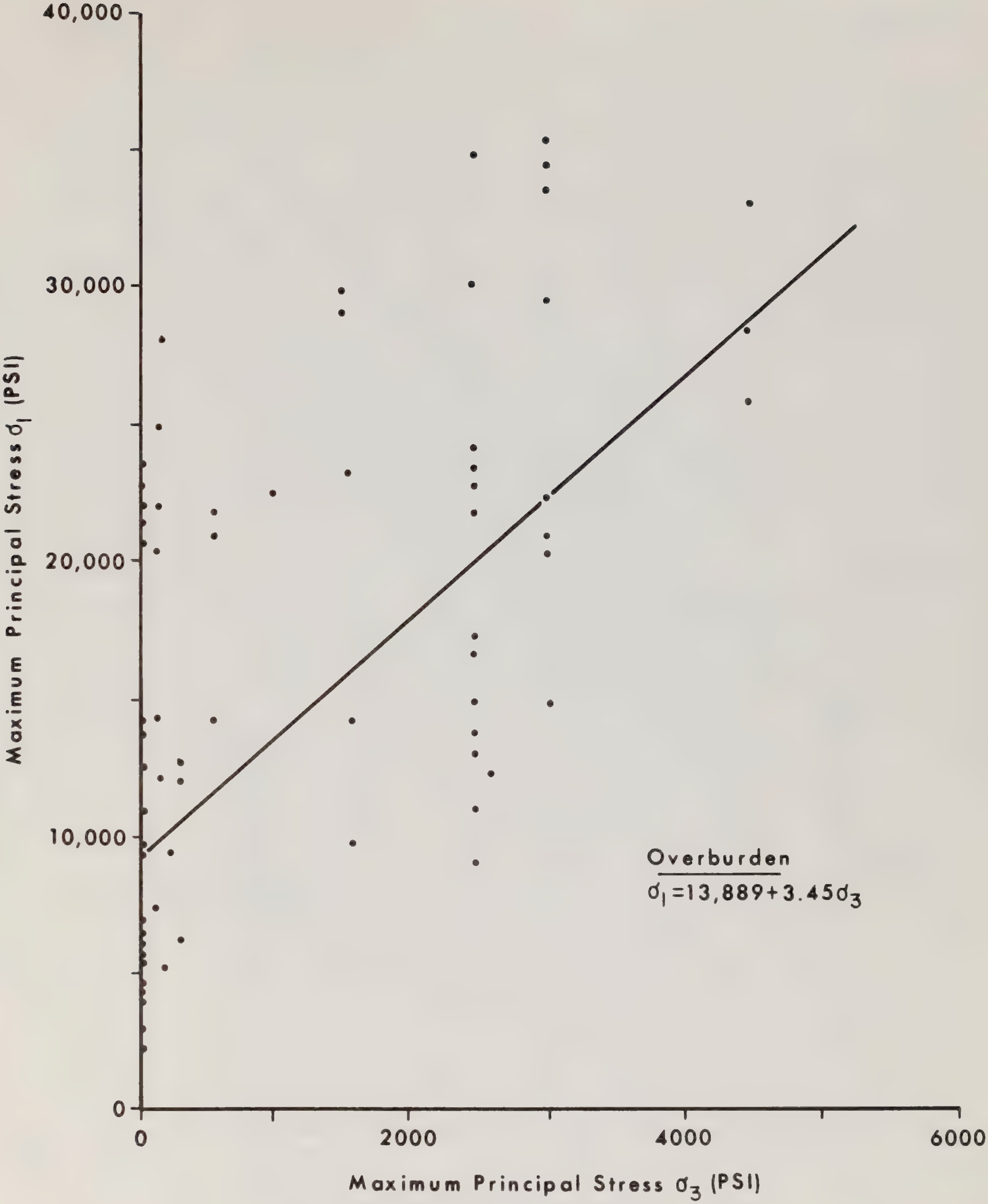



Figure 2-5-1
Results of Uniaxial and Triaxial Compression Tests on Overburden Material

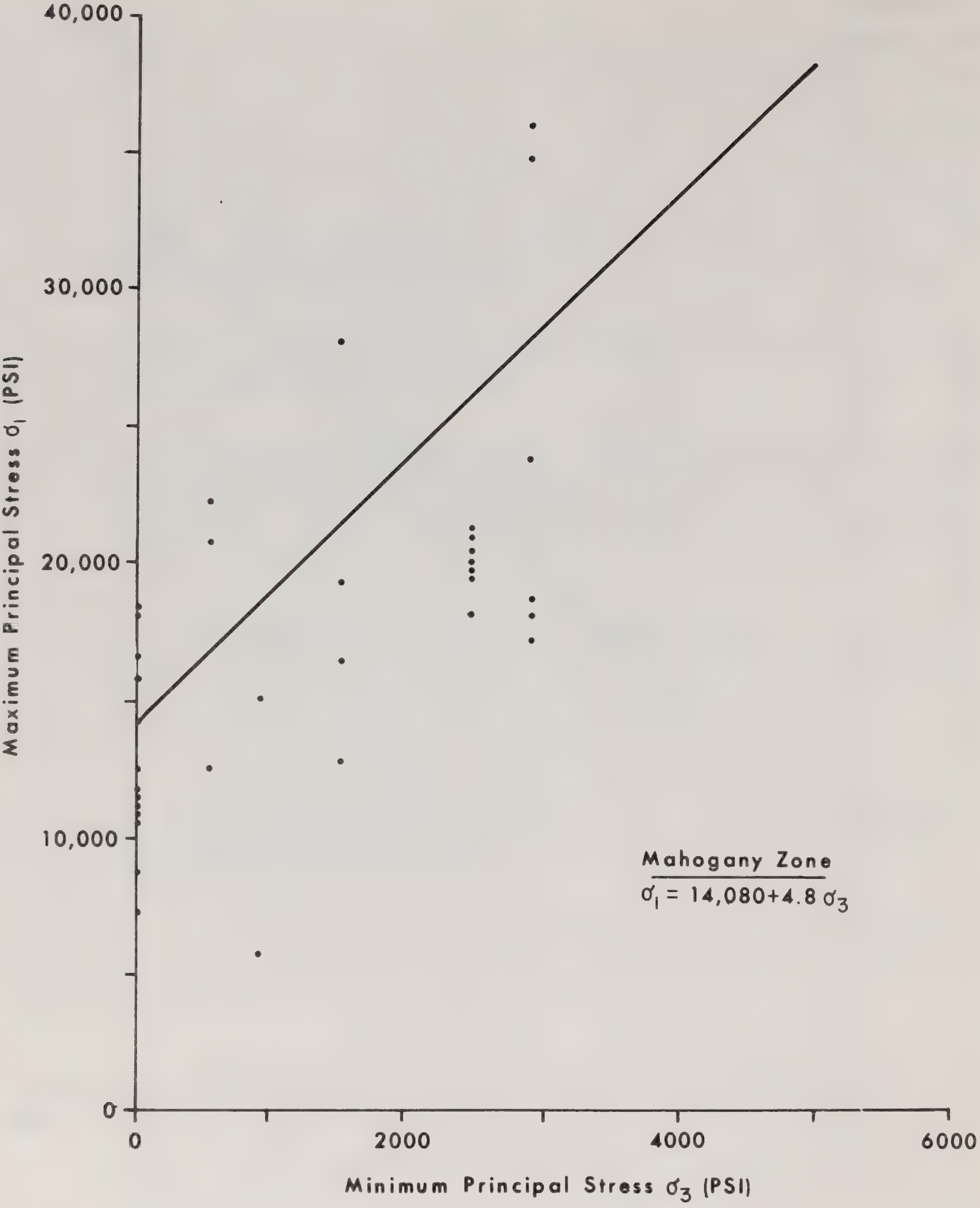



Figure 2-5-2

Results of Uniaxial and Triaxial Compression Tests on Mahogany Zone Material

Table 2-5-2

SUMMARY OF DATA ANALYSIS FOR DIRECT SHEAR TESTS ON ROCK SAMPLES FROM THE VARIOUS ZONES OF TRACT C-a

| | | | | AT FRACTURE INITIATION | | | $T = S_0 + B\sigma_N + C\sigma_N^2$ | |
|---|---|---|---|---|---|---|---|---|
| ZONE | DEPTH (FT.) | DRILL-HOLE | FRACTURE SURFACE ORIENTATION TO STRATIFICATION | $\sigma_N$ (PSI) | $\tau_{MAX}$ (PSI) | $S_0$ (PSI) | B ($PSI^{-1}$) | C ($PSI^{-1} \times 10^{-5}$) |
| R-6 | 689 | GS 4-5 | PARALLEL | 600 | 1,260 | 10 | 0.753 | -10.97 |
| R-5 | 909 | GS 4-5 | $60^0$ | 1,000 | 1,920 | 52 | 0.848 | -6.06 |
| L-3 | 1,210 | GS 4-5 | PARALLEL | 1,200 | 2,730 | 86 | 0.432 | -0.44 |
| R-3 | 1,313 | GS 4-5 | PARALLEL | 1,300 | 3,480 | 125 | 0.936 | -8.47 |
| L-2 | 1,561 | GS 11 | PERPENDICULAR ON EXISTING FRACTURE | 500<br>1,000<br>1,500 | 200<br>380<br>605 | 0 | 0.454 | -4.80 |

tests on core from zone L-2 were conducted on an existing fracture perpendicular to stratification.

The results of these tests indicate the friction angle "Ø" of the jointed rock is quite high, possibly in the range of intact or unjointed rock. The average coefficient of sliding friction, as determined from the test results, is about 0.7 or an angle of internal friction of 35 degrees for both open and filled joints.

For the samples with the fracture surfaces oriented parallel to stratification an average value for cohesion of 74 psi was determined from the tests. For the sample with the fracture surface oriented 60 degrees to stratification the cohesion value was determined to be 52 psi. The tests conducted on the sample with existing fracture perpendicular to stratification demonstrated 0 psi cohesion. Tests on other oil shale samples from the area have shown cohesion along joint surfaces to be well above 10 psi.

B. Analytical Methods - The geologic structure of the pit area was reviewed to determine the relationship of major structural features and the pit location. Surface structural mapping and photogeology to date have defined only two minor faults in the pit area with displacements of only five and ten feet (see Section 2, Chapter 3).

Other structural features considered which affect pit stability are joints or naturally occurring rock fractures. Joints have been mapped at 42 outcrop stations across Tract C-a and their characteristics found to vary locally. To obtain a site-specific definition of the joint patterns in the pit area, data from 11 stations within Area 1 of Figure 2-5-3 were used for the analysis. Results of the analysis are summarized on Figures 2-5-4, 2-5-5 and 2-5-6.

The rose diagram of Figure 2-5-4 defines a joint system consisting of two joint sets. About half the joints strike or trend between N40-70°W and comprise the dominant or primary joint set. About 20% of the joints strike between N10-40°E and comprise the secondary joint set. The equal area nets

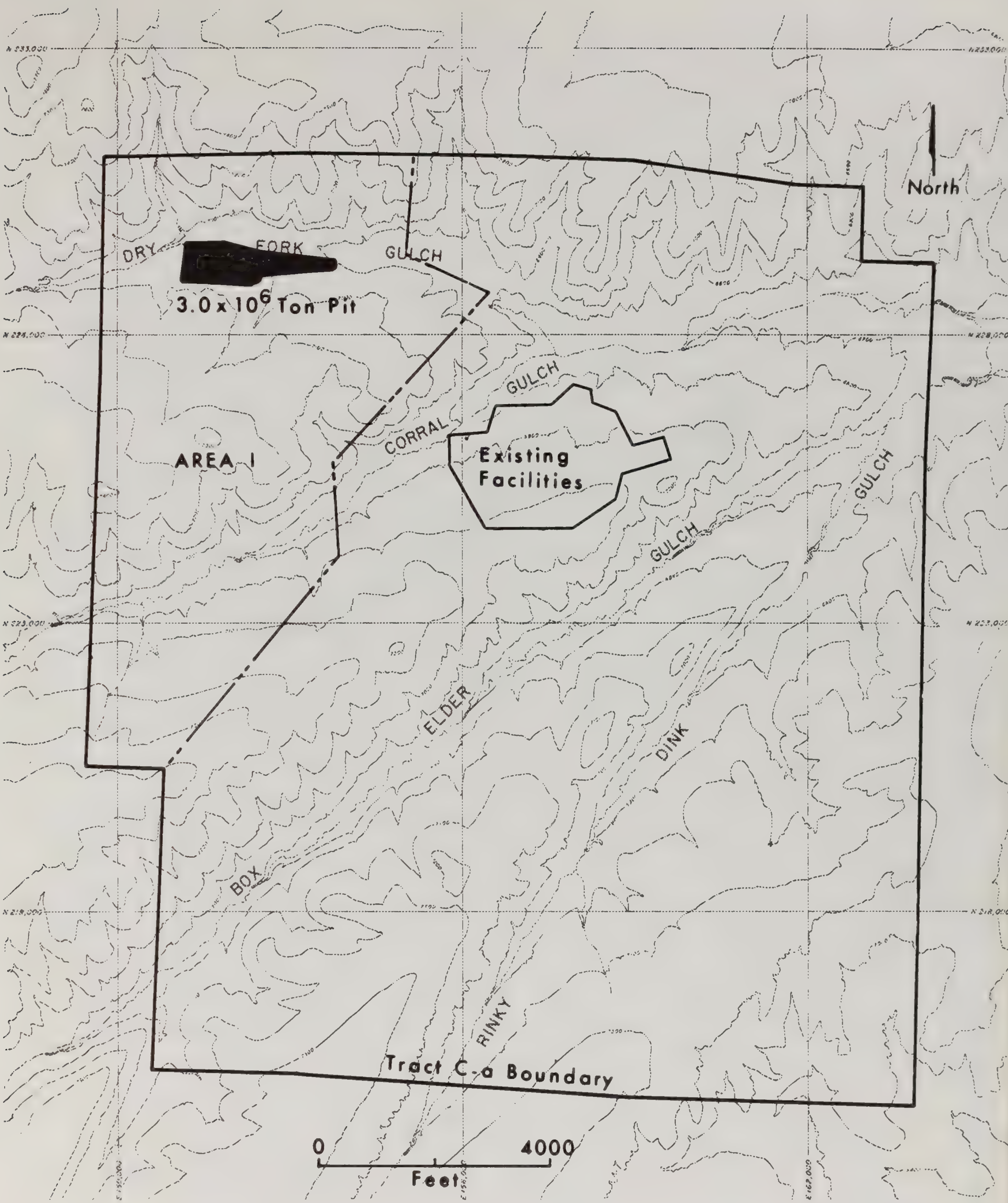



Figure 2-5-3
Location Map For Area I Tract C-a

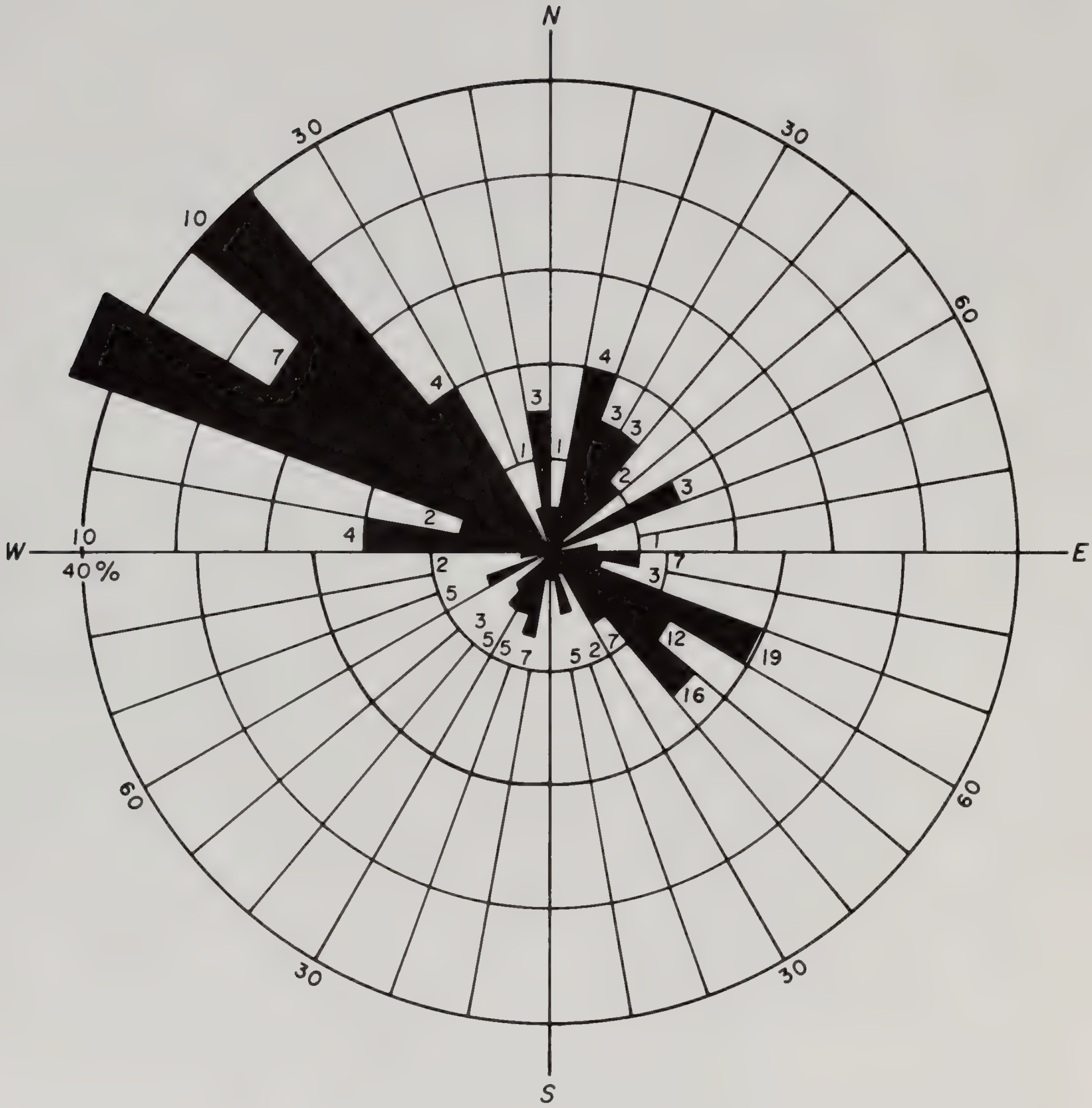



Figure 2-5-4
Joint Orientation by Number & Percent   Area 1

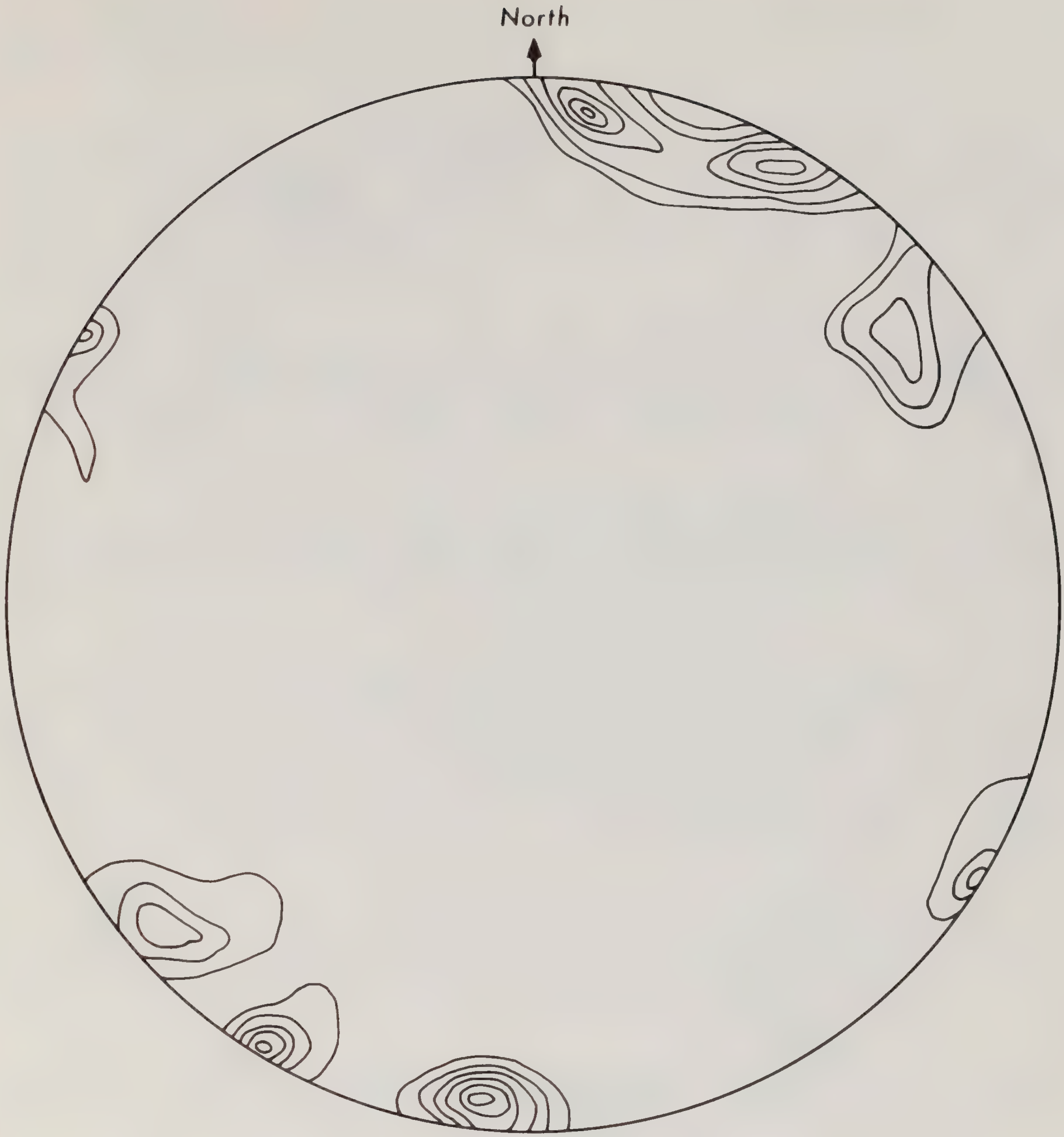



Figure 2-5-5
Presentation on Equal Area Nets by Number
Contour Interval - 10 Area 1 Lower Hemisphere Projection

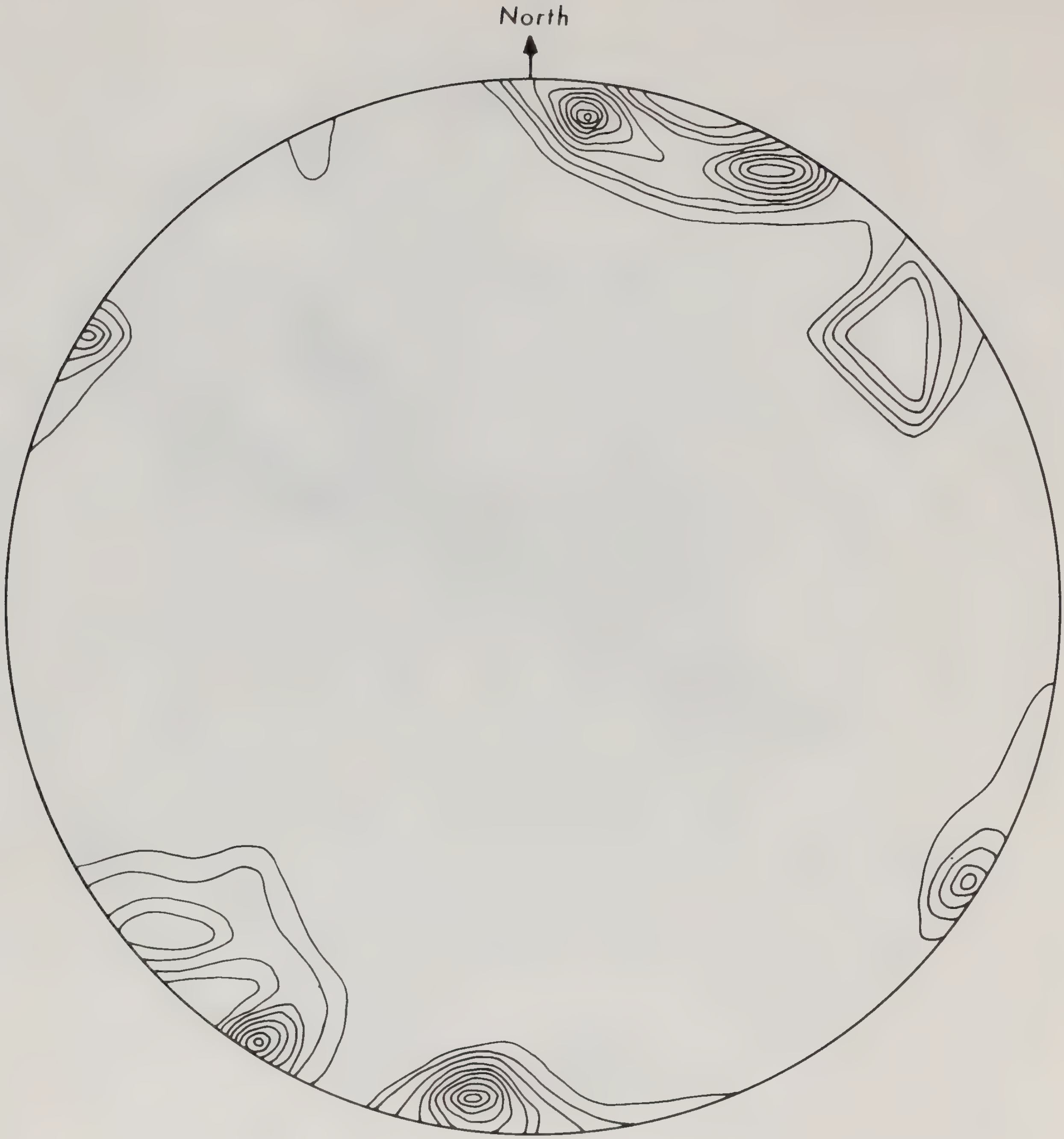



Figure 2-5-6
Presentation on Equal Area Net by Percent
Contour Interval - 2% Area 1 Lower Hemisphere Projection

of Figures 2-5-5 and 2-5-6 (by number and percent contours on lower hemisphere projections) indicate the planes of most of the joints dip at high angles ranging from about 70° to vertical.

Spacing between joints varies considerably throughout the area analyzed. Joints striking northwest are generally spaced from 2' to 50' apart with an average spacing of 5'. Those striking northeast are spaced from 3' to 30' apart with an average spacing of 8'.

The above described faults and joint patterns, as well as information obtained from drill hole logs, were used to determine potential failure surfaces in the excavation of the pit.

C. Methods of Analysis - A limiting equilibrium method of slope analysis, utilizing both wedge and circular types of failure modes, was used for the study.

The circular failure mode was not considered in the analysis of the operating slopes. The shear strength of the intact oil shale measured in the laboratory was high, therefore it was assumed that failure is more likely to occur along planes of weakness, rather than a circular failure through the intact rock.

A circular failure analysis was used to evalute the stability of the reclaimed slopes as it involved in situ as well as fill material.

A computer program was implemented to investigate a circular failure mode on the entire reclaimed slope and within the fill portion of the slope only.

A wedge failure analysis was conducted for the reclaimed and operational highwall slopes. A program designed for a Hewlett-Packard Calculator was used to determine the factor of safety as a function of wedge geometry, strength parameters, and water pressures. Program input requires the dip and dip direction of failure planes and the slope face. The program first determines whether the formation of a wedge is kinematically possible and if a wedge is formed, slope height, phreatic surface and rock strength parameters are input and a factor of safety is calculated.

D. Discussion of Results - Slope models were formulated to represent the highwall. The following factors were included in these models:

- Slope height and angle
- Physical properties of the rock
- Hydrologic conditions

A discussion of each of the slope models follows:

1. Overall Pit Slope - The overall highwall slope model analyzed was a 400 foot high, 60 degree slope with the phreatic surface assumed to be at the original ground level. The joint sets in Figure 2-5-4 as well as the two northwest-trending vertical faults were treated as weakness planes for all sides of the pit. Analyses were done assuming very conservative values of one psi cohesion and a Ø angle of 20 degrees. The factor of safety is calculated to be 1.5 which is in the stable range. Direct shear tests now being conducted on site-specific cores indicate cohesion values well in excess of 10 psi.

2. Interbench Slopes - The interbench slopes were studied using a 100 foot, 70 degree slope with saturated conditions. Assuming a cohesion of five psi and a Ø angle of 20 degrees a safety factor of 1.7 was determined.

3. Reclaimed Slopes - The model used to represent the reclaimed slopes was an 18 degree lower fill slope and a 45 degree upper rock slope for a height of 150 feet. Only the rock slope is subject to wedge failure. A factor of safety of 2.9 was determined for one psi cohesion and Ø of 20 degrees.

E. Conclusions - From the foregoing analyses, it can be concluded that under the assumed conditions, a 100 foot, 60 degree overall slope; a 100 foot, 70 degree interbench slope, and a 150 foot, 45 degree reclaimed slope as designed should be stable.

F. Slope Monitoring - A program of slope stability monitoring will be initiated as the open pit mining begins. The purpose of this program will be to determine the performance of the slopes. The program will include detailed structural geologic mapping of the pit slopes as they are excavated during stripping and production mining. Around the rest of the pit, particularly where high slopes will develop, a system of survey points will be established and precisely surveyed by conventional surveying methods to detect any horizontal and/or vertical movement. It is anticipated that second order survey accuracy will be applied. On-site visual observations will also be made regularly.

## 6.1 OPEN PIT DESIGN

The major considerations in mine planning of the Lurgi demonstration pit were the proximity to the plant facility and the availability of oil shale at low strip ratios.

A. Mine Development Scheme - Present plans and concepts for the development of the open pit mine may be illustrated in two development phases: Phase I, a 20 month program to mine 1.2 million tons of oil shale; and Phase II, an 18 month program to mine 1.8 million tons of oil shale for a total of 3.0 million tons. These phases are described as follows:

1. Phase I, 20 Month Development for 1.2 Million Tons. (Figures 2-6-1 and 2-6-2) - To minimize the preproduction stripping required for initial production and the time period required for this stripping, the Phase I pit will be located on the south side of Dry Fork of Corral Gulch. The Phase I pit was oriented on the south side of Dry Fork based on the following factors:

- Minimal overburden depth to the oil shale
- Minimization of environmental effects
- Proximity to plant site selected

The pit location was selected on the basis of available hydrologic and geotechnical information. However, as discussed in Section 2, Chapter 8, a slight change in location is being evaluated.

This design requires the removal of approximately 5.2 million bcy of overburden before the 1.2 million tons of oil shale can be mined. See Chapter 7 for schedules.

2. Phase II, 18 Month Development for 1.8 Million Tons. (Figures 2-6-2 and 2-6-3) - The development of the Phase II pit involves expansion of the Phase I pit. Both the west and south highwalls will be pushed back to expose

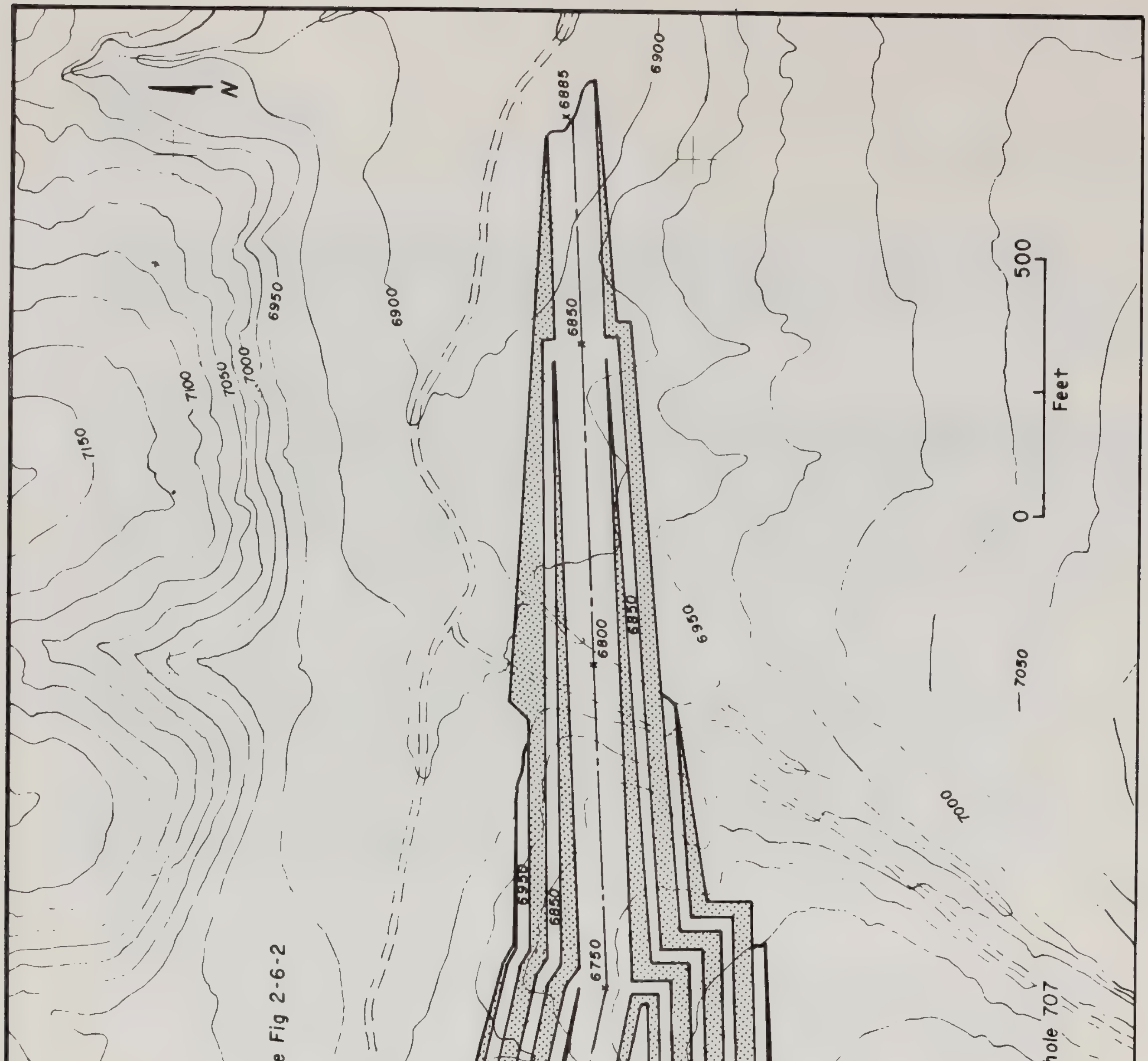



Figure 2-6-1
Phase I Pit Fully Developed

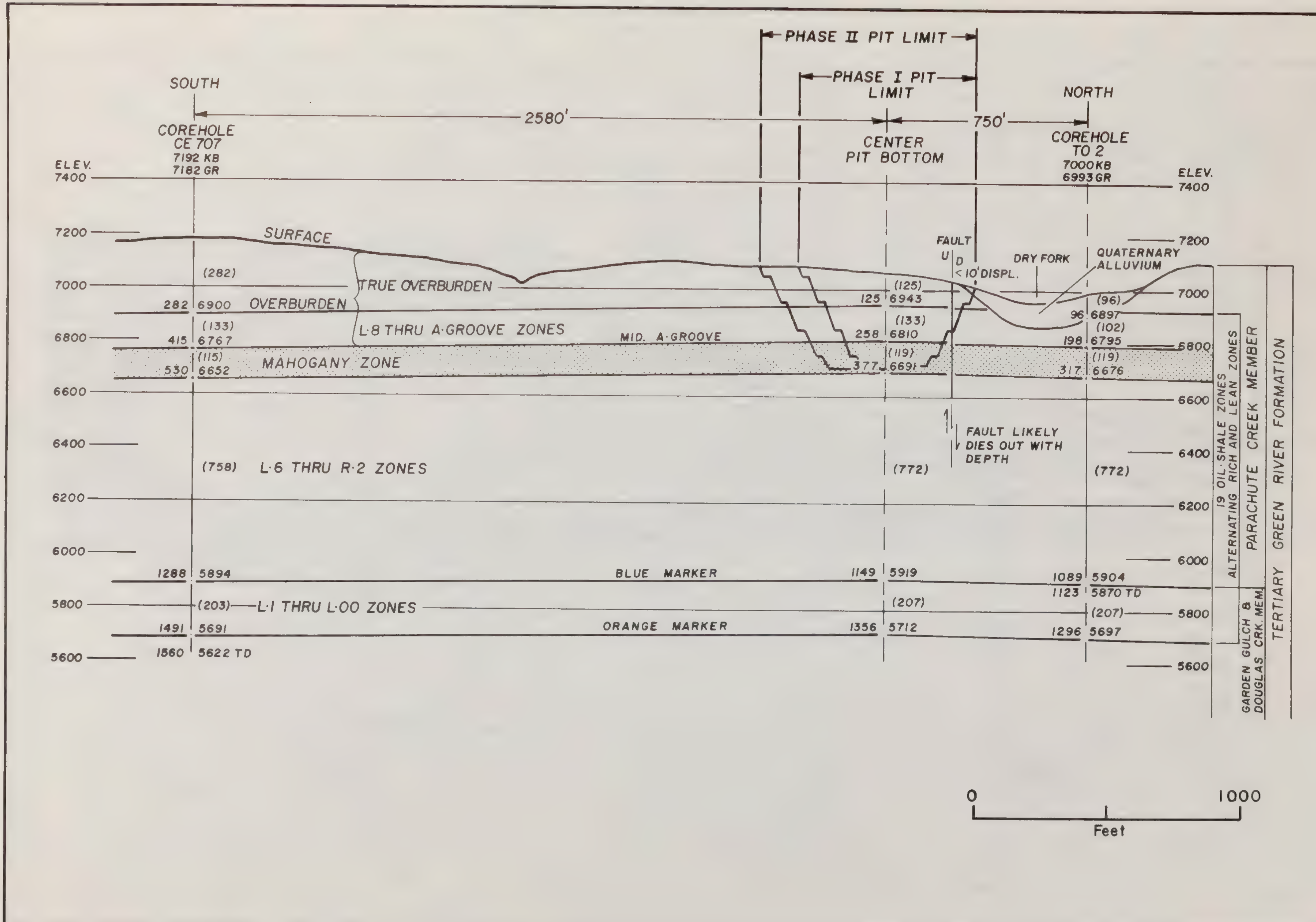



**Figure 2-6-2**
**Pit Development Phases I and II**

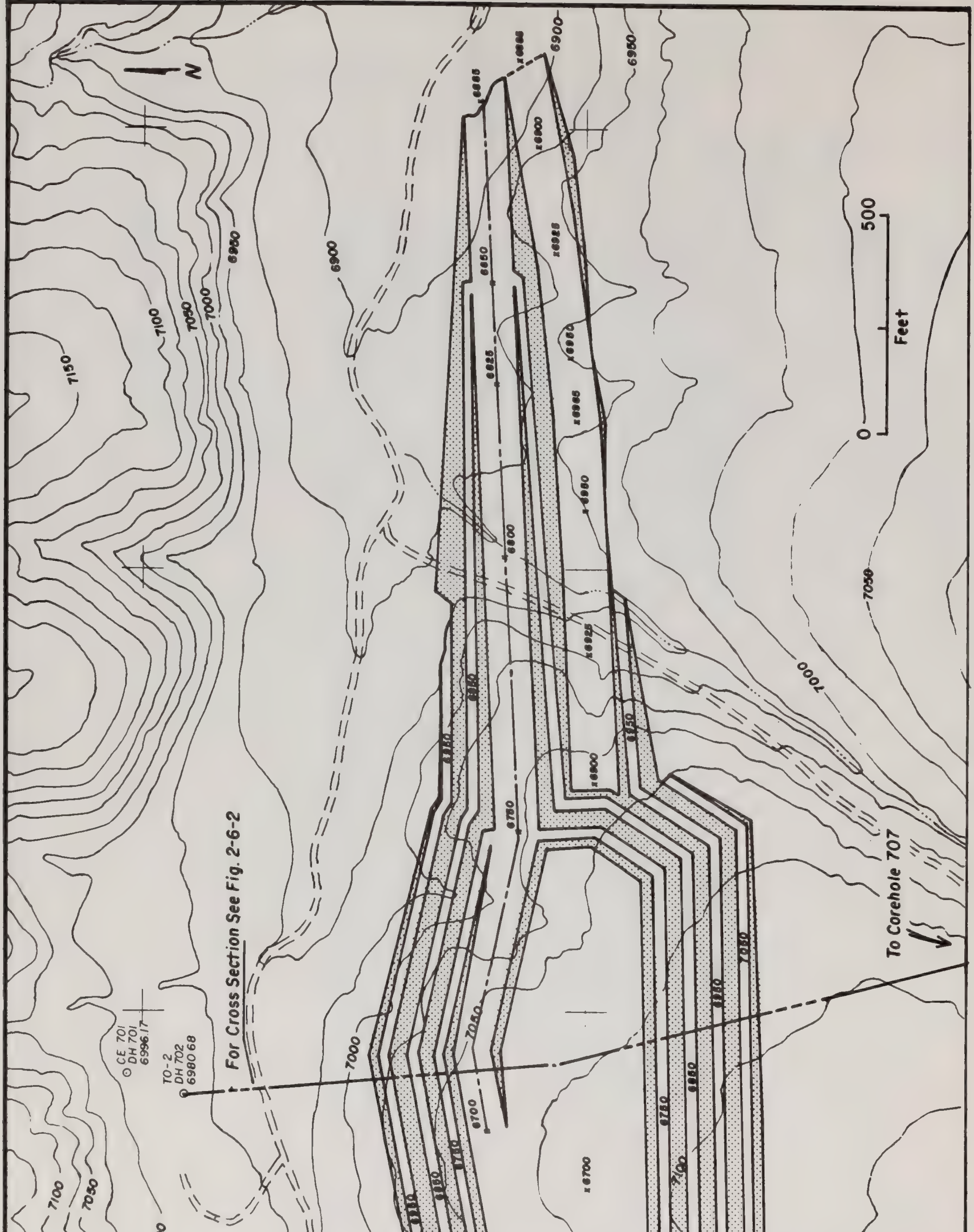



**Figure 2-6-3**
**Phase II Pit Fully Developed**

an additional 1.8 million tons of oil shale for mining. This design requires the removal of approximately 4.2 million cubic yards of additional overburden to expose the 1.8 million tons of oil shale. See Chapter 7 for schedules.

The criteria used in the design of the pit are as follows:

- Oil shale production requirements and feed stock grade based on retort production schedule
- State and Federal regulations governing mining operations in Colorado
- Operating bench height of 25 feet
- Safety bench width of 25 feet
- Final bench height of 100 feet

B. Detailed Mining Scheme - The following describes the mining methods and equipment proposed for the open pit operation. The methods and equipment described represent those presently thought to be best for the Lurgi Demonstration Project. The open pit mining operation utilizes conventional open pit drilling, blasting, loading and hauling techniques to produce 3.0 million tons of oil shale. As more is learned about the deposit and related operations, the details of equipment and its application may be varied to meet conditions.

1. Preparation Activities - Before mining activities can start, the affected areas will be cleared and grubbed of any vegetation, stripped of all recoverable topsoil for postmining reclamation and appropriate surface water control structures will be installed. For details on runoff ponds and diversion and collection ditches see Section 7, Chapter 6. All mining activities will be in accordance with all applicable State and Federal regulations.

2. Drilling and Blasting - The drilling and blasting scheme developed for the open pit is based on available data from the mining industry, known physical properties of Tract C-a rock and textbook blasting theory.

The typical blast hole will be vertical and about 29 feet deep. This depth allows about 4 feet of subgrade for breaking to the designed toe of the 25 foot bench.

A rotary, diesel-powered, rubber-tired blast hole drill is proposed. The drill is capable of drilling a 10 inch diameter downhole to the design depth in a single pass. The typical drilling pattern for overburden and oil shale is a multiple-row, staggered pattern of 20 foot by 25 foot burden-spacing. A 40 hole production shot provides about 18,500 cy of broken material for loading. This requires 3 to 4 blasts per week to meet production requirements.

A mixture of ammonium nitrate and fuel oil (ANFO) will be used as the primary explosive to charge dry blast holes. Water gel explosives will be used as the primary explosive to charge wet blast holes. Initiation of the blast holes will be by electric blasting cap via suitable primers. The scheduled time of blasting will be at the end of the day shift during shift change. This complies with the State of Colorado regulations requiring blasting operations during daylight hours. Sequential detonation will be utilized to enhance fragmentation and to reduce air concussion, noise level and ground vibration.

The drilling and blasting operations will comply with existing Federal, State and local regulations pertaining to handling, storage and use of explosive materials.

3. Loading - The primary piece of loading equipment selected for this operation is a 12 cy hydraulic, diesel-powered shovel front loader. A 12 cy front-end loader has been chosen as an auxiliary loader. During Phase I and II operations the upper benches will be completely excavated before moving to the next lower bench. The loading operation will require the use of a track mounted dozer for pit clean up around the shovel. Loading for overburden and oil shale will be scheduled on a 2 shift per day 5 day per week operation.

4. Hauling - The haulage system developed for the open pit mine utilizes truck haulage. Truck haulage provides economical transportation for hauls under 3 or 4 miles where steep grades are encountered. The selected units are off-road, enddump, haulage trucks of 85 ton capacity. Overburden and oil shale will be hauled to the RBOSC off-tract property for disposal and stockpiling respectively. A fleet of 11 haulage trucks will be used during the operation.

The average length of haul, one-way, is approximately 9,600 feet, with a maximum grade of eight percent. The empty haulage trucks return along the same route. The only exceptions to this plan are at the start of operations and during Phase II operations. At the start of the overburden removal operations, approximately 640,000 bcy will be used to construct the haul road and at the start of Phase II operations approximately 2.0 million bcy will be stockpiled on tract for pit backfill during the reclamation period.

C. Support Operations - The following items are descriptions of major support operations pertinent to the open pit mining operation.

1. Mine Facilities - Mine facilities will consist of a 12,000 square foot shop/warehouse building, two 12x60 office trailers, two 12x60 change house trailers, a 70,000 gallon fuel storage system, a bulk ammonium nitrate storage system, an explosives storage system, and parking area for the mining equipment and employee vehicles.

The explosive storage system will be separate from the open pit mine facilities area. The mine facilities area will encompass approximately 3.0 acres (see Figure 2-6-4). The facilities area will be elevated by fill to allow easier access to the haul road. The fill for the facilities area will be overburden from the open pit. Access to the facilities area will be provided by improving the existing public access road located on the Corral Gulch valley floor. All buildings will be provided with heat, lighting, communications, potable water, sanitary facilities and fire protection as required.

The shop/warehouse will be a preengineered metal building. The office and change house structures will be trailers. The fuel in permanent tank storage will be contained in two 30,000 gallon diesel tanks and one 10,000 gallon gasoline tank.

During the initial construction period, diesel fuel and gasoline will be stored in skid mounted tanks at the site. Motor oil and other fluids will be stored in durable containers, as shipped from suppliers. All fuel tanks will be surrounded by impermeable berms to contain accidental spills (see Figure 2-6-5). All storage and handling of fuel and other flammable products will

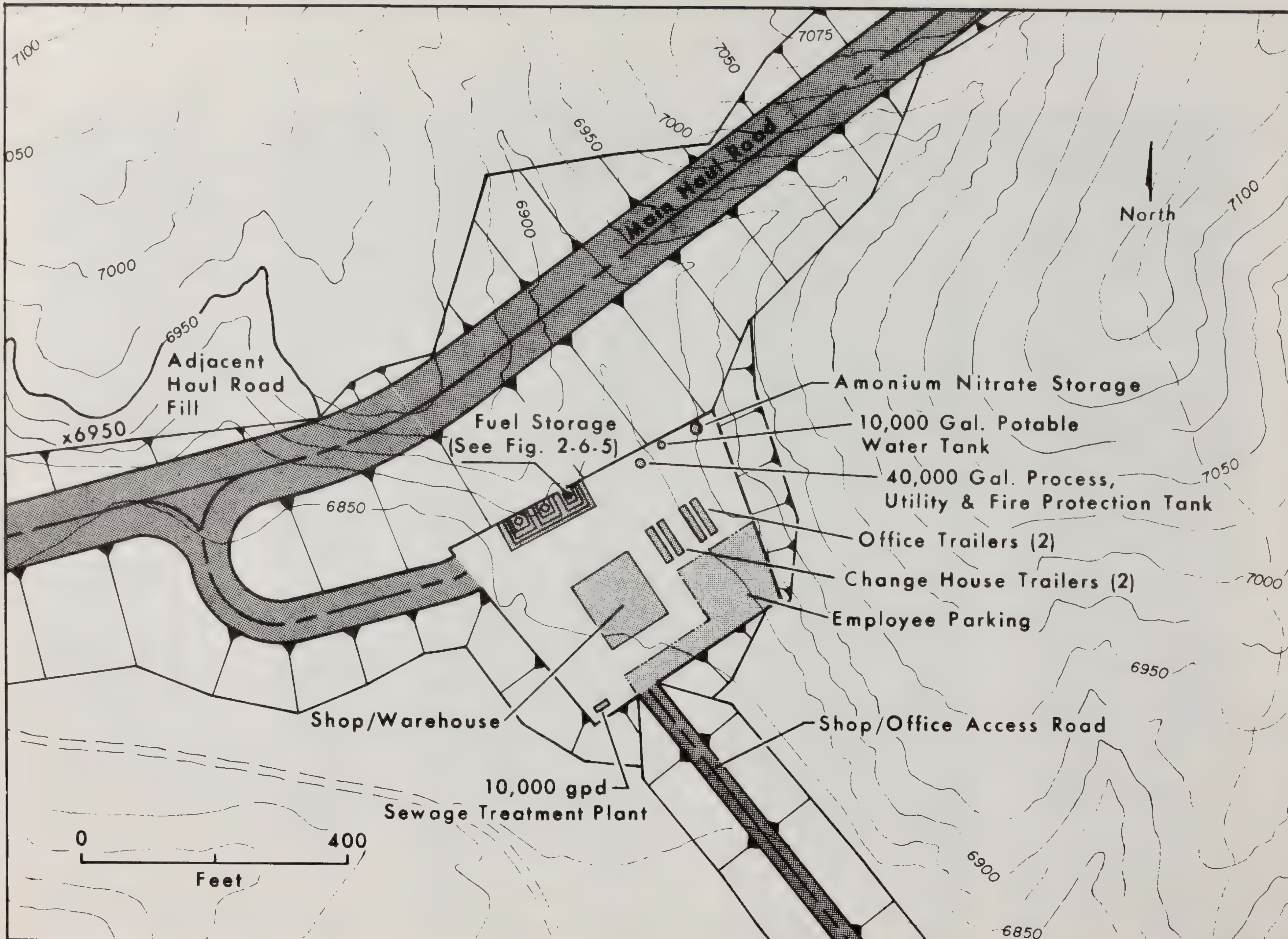



Figure 2-6-4
Facilities Area

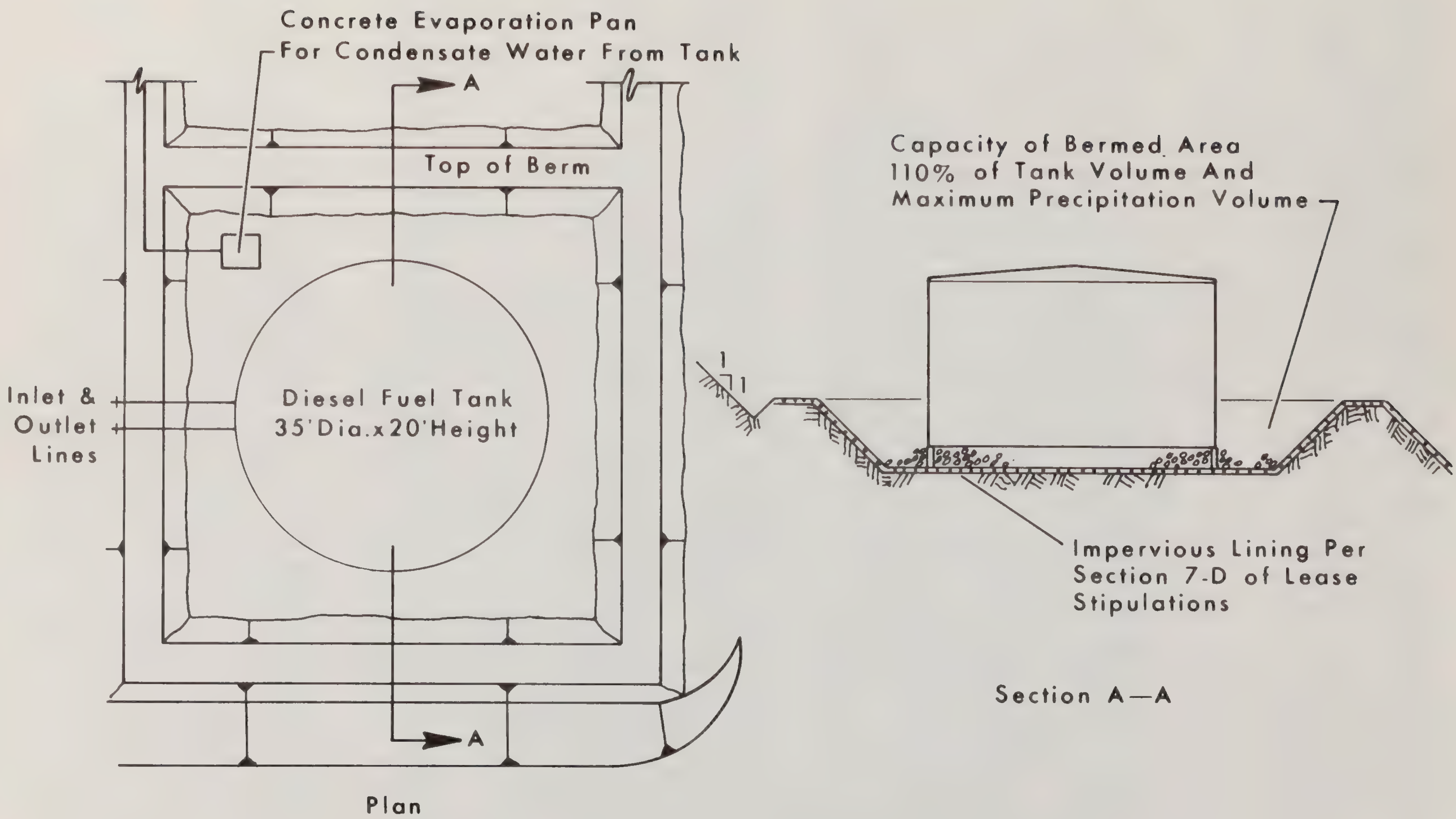



Figure 2-6-5
Typical Fuel Storage Tank

comply with lease stipulations, industry standards and State and all other applicable government regulations. Service station facilities will be designed and constructed in accordance with applicable National Fire Protection Association standards.

Regulations governing design of the facilities include the following:

- Tract C-a Oil Shale Lease
- Design standards of the American Petroleum Institute, Division of Refining
- Fire Protection Handbook, National Fire Protection Association, Thirteenth Edition
- National Fire Codes, National Fire Protection Association
- Colorado Mining Laws, Bulletin 20, Colorado Bureau of Mines
- Title 30, Part 55, Health and Safety Standards for Metal and Non-Metal Open Pit Mines, Bureau of Mines, U.S. Department of the Interior
- Title 29, Part 1926, Subpart F, Construction Safety and Health Regulations, Occupational Safety and Health Administration, U.S. Department of Labor
- Safety and Health Rules and Regulations, Colorado Occupational Safety and Health Administration
- 43 CFR, Part 23
- 30 CFR, Part 231

2. Mine Roads - The mining operations internal road system will consist of haul roads for transporting overburden and oil shale and various service and access roads serving the mining operation.

The only public access to the mining operation will be via an entrance near the northeast corner of Tract C-a. All visitors will be required to register at a guard center before being allowed to enter the mine operation area. The guard center will be located near the east side of Tract C-a.

The haul road was designed for an 85 foot driving width with safety berms placed on fill sections. The berm height is set at one-half the height of the 85 ton haul unit tire. The haul road is approximately 9,000 feet long and will be surfaced with crushed rock to act as an all weather operating surface. Chemical dust suppressants and water will be used as needed for dust control.

Maximum vertical grades will be 8% on all permanent (life of mine) internal mine operation roads. All internal mine operation roads will be designed for a maximum operating speed of 30 mph. Drainage control of the haul road is discussed in Section 7, Chapter 6. Preliminary design indicates that approximately 5,000 feet of culvert ranging from 2 to 6 feet in diameter will be utilized for drainage control of the haul road. In Phase II a haul road will be constructed to haul overburden into the East Gulch fill area. It will be designed according to the same specifications as the haul road from the mine to the Lurgi plant site.

In compliance with lease stipulations and BLM regulations, existing roads and trails will be left open until they enter an area that could present a hazard to the public. In such areas, with DCM/OS approval, warning signs will be posted and/or the road barricaded. Type of control will depend on the degree of potential hazard. During construction, flagmen or other warning procedures will be used as necessary to protect the public and employees. Uncontrolled use by offroad vehicles will be restricted. Existing and potential trails will be posted with restrictive warning signs. When and where necessary, fences, mounds or trenches will be installed to prohibit use. Where public access is affected, areas will be closed only with approval of the BLM and DCM/OS.

When mining disturbances force any existing roads to be closed, an alternative road will be constructed to insure continued access to all lands. For additional information on the road system refer to Section 6, Chapter 2.

3. Mine Drainage - A combination of mine depressuring wells and inpit sumps will be required for mine drainage. The water supply wells will be located north of the pit to initiate mine depressing. Any additional wells

required will be installed on inactive benches. It is estimated that a maximum of five additional wells may be required, each pumping an estimated 270 gpm. Inpit sumps will be required when the pit vertically advances below the 6,850 level. The sump will be located in the bottom of the open pit. Total pumping capacity will be planned for a maximum pumping rate of 3,000 gpm although normal pumping rates are expected to be in the range of 1,500 to 2,000 gpm. Trenches will be excavated to channel seepage water into the sump area on a continual basis to assure adequate working floor conditions.

4. Mine Power Distribution - All proposed mining equipment will be diesel powered thus eliminating the need for a complex power distribution network. The only requirements for electrical power at the open pit would be power for pit lighting and dewatering operations. It is estimated that a 625 KVA power line to the pit area will satisfy requirements. For the mine facility, a 375 KVA power line will be required. Power for the open pit and mine facilities will be tapped from the power line constructed from the existing MIS mine site to the proposed Lurgi process facility.

5. Maintenance - The mine maintenance facility will be a 12,000 square foot shop/warehouse. The building will include: (1) facilities for maintaining 85-ton enddump trucks, crawler tractors, motor graders and miscellaneous support equipment; (2) overhead bridge cranes, (3) a tool crib; (4) machine, electrical, and welding shops; and (5) warehouse storage.

Sufficient space will be allocated near the shop/warehouse to park the mobile equipment when not in use. Hot start units will be provided to keep motors warm during periods of severe cold weather. Equipment that cannot reach the shop/warehouse will be maintained and serviced by mobile units in the field.

6. Safety

a. Policy - The contractor is guided by an established safety policy. The goal is to prevent personal injuries, occupational illnesses and equipment or property damage.

Management and supervisors are charged with the responsibility of preventing the occurrence of incidents or conditions which could lead to injury or illness. While the overall success of a health and safety program depends upon the cooperation of the individual employee, it is management's responsibility to provide a safe work environment. It is also management's responsibility to establish and enforce adequate rules and procedures and to provide training and educational programs.

Safety will not be sacrificed for production. Each supervisor will be accountable for the safety performance of the employees under his supervision.

b. Health and Safety Program - The contractor will develop a program covering the following aspects of project health and safety:

Site Specific

- RBOSC/contractor management relationship/responsibilities/duties
- Supervisory duties/responsibilities
- Technical support, purchasing, maintenance
- Health and safety regulations - Federal, State of Colorado, RBOSC, contractor
- Accident analysis/prevention, recordkeeping, reports
- Contractor/subcontractor relationship/responsibilities/duties

Security and Emergency Medical Assistance

- RBOSC/contractor/subcontractor employee security
- Visitor/vendor protection control
- Site protection-fire, theft, vandalism, intrusion
- First aid stations/infirmaries
- Emergency transportation
- Supervisory first aid training

c. General Practice - Section 7, Chapters 2, 3 and 4 and Section 6, Chapters 5 and 8 explain in detail, each segment of the program proposed for this project. The following are brief statements concerning general practices under that program.

1) Fire Fighting - The contractor will establish and maintain a system for fire prevention and control to include:

- Review of all pertinent legislation
- Enforcement of Federal, State of Colorado, RBOSC and contractor rules and regulations
- Training and education
- Maintenance of tools, equipment and systems
- Supervision of construction methods and practices

2) Explosives - The handling, storage and use of explosives will be closely managed for maximum safety and to comply with State and Federal agencies and RBOSC/contractor policy.

3) Noise - Appropriate engineering and construction practices will be employed to minimize noise generated during each phase of the project. Levels will be periodically monitored for personnel health protection. If excessive noise levels are generated employees will be required to wear protective equipment designed for such exposure.

4) Airborne Particulates - Where employees are exposed to potentially dangerous fumes and dusts, RBOSC will set up a monitoring program to determine concentrations and exposure levels. If the employees are exposed to such dangers, they will be required to wear protective equipment designed for such exposures.

7. Communications - A two-way FM radio system with base stations, mobile units, walkie-talkies and repeater stations will provide internal mine operation communications. This system will be used to direct mining operations for maximum efficiency.

Mountain Bell Telephone Company will provide telephone service to Tract C-a. The line serving the tract will be a buried cable installed adjacent to or, wherever possible, within the road right-of-way; thus providing good access for construction and maintenance. Temporary radiotelephone facilities will be provided to handle communcations during the early phases of construction.

D. Resource Recovery - This part contains RBOSC proprietary information and is being submitted to the OSO as confidential material.

# CHAPTER 7
# SCHEDULES

## 7.1 DEVELOPMENT AND CONSTRUCTION

Starting May 1, 1981 a four month construction phase will begin. During this period, initial clearing and stripping of topsoil will take place, roads will be constructed, drainage control strucutres will be built and facility structures will be erected.

## 7.2 MINE PRODUCTION AND FEED SCHEDULE

Phase I overburden stripping operations will begin concurrently with the construction phase and will end early in 1983. Initial overburden removed from the pit will be used in access road and mine facilities area construction. The remaining overburden will be used in haul road construction, Lurgi plant construction and overburden dike construction. After removal of all overburden 1.2 million tons of oil shale will be mined and stockpiled at the Lurgi facility over a period of three months. Phase I mining therefore should be complete in April 1983.

Phase II overburden stripping will not begin until six months after the end of Phase I. During this period the operability of the retort will be evaluated and the need to proceed with Phase II operations will be determined. It will start in November 1983 and end 15 months later. By February 1985 an additional 1.8 million tons of oil shale will be exposed and will be mined out by May 1985. The mining schedule is shown on Figure 1-1-6.

# MAJOR ALTERNATIVES AND SELECTION RATIONALE

In selecting an open pit operation as the method to supply shale to the Lurgi retort, three alternatives were evaluated. They were:

1. Increased shale production from the existing MIS facility
2. Development of a room and pillar underground mine
3. Develop an open pit

Evaluations of the three alternatives follow.

Expand MIS Operation - A logical supply of shale for the Lurgi retort would be from the existing MIS mine facility if it had been designed as a high production operation. In reality the MIS mine is designed to handle only retort withdrawal material and would be undersized in both hoisting and ventilation capacity if expansion of the mine were attempted. In addition, the MIS mine is an ongoing test operation that requires full utilization of the existing facilities.

Develop New Room and Pillar Mine - A new underground room and pillar mine was rejected for a number of reasons including economics. Anticipating that such a mine would likely be declared gassy, as with the MIS mine, relatively low productivity and high capital costs would be expected as a result of the limitations of Schedule 31 equipment.

As far as resource recovery is concerned, the room and pillar method of mining is the most wasteful of the three alternatives.

Open Pit Mining - The open pit method was chosen because it allowed the most economical production of shale, it is a relatively safe, proven mining method and it can be scaled up to meet the requirements of a commercial operation. It is also the mining method that will allow the highest resource recovery on the tract.

The open pit location was selected on the basis of geotechnical and hydrological information available in late 1980, with the objective of minimizing overburden removal, environmental effects of the open pit, and haulage distance to the Lurgi processing facility. The open pit location identified in this document basically meets these site selection criteria. Although it has been recognized that a location approximately 500 feet to the north, in the middle of Dry Fork, would reduce overburden removal requirements very substantially, this location was not chosen initially because the information available at that time indicated the alluvial deposits within Dry Fork might contain an alluvial aquifer. Therefore, to minimize disturbance to the ground water system, the open pit was located out of Dry Fork. Recently, however, a drilling program was conducted to better define the alluvium, the results of which have shown that the alluvium in Dry Fork is dry. Therefore, Rio Blanco is currently re-evaluating this site as an alternate to the site identified in this document. Should this analysis show that the Dry Fork location is more favorable, RBOSC will submit the open pit plan changes to the OSO.

# Section 3

# RETORT FEED PREPARATION

# CHAPTER 1
# SYSTEM DESCRIPTION

The function of the oil shale retort feed preparation system is to produce, from the run-of-mine (ROM) oil shale stockpile, properly sized oil shale, then store and feed this material to the Lurgi processing unit.

Major functions of the system operation include the following:

- Reclaiming from ROM oil shale stockpile
- Crushing and screening
- Crushed products storage
- Reclaiming of crushed oil shale
- Feed to retort

Figure 3-1-1 is a schematic illustration of the retort feed preparation system. Basic design criteria and capacities of major equipment are also shown. Parallel crushing and screening circuits were selected to evaluate two types of crushers and provide system availability.

The system will be designed to produce crushed oil shale meeting the following specification:

| | | |
|---|---|---|
| Minus 1/4" (6 mm) | - | Nominal |
| Larger than 1/4" (6mm) | - | No more than 10% |
| Smaller than 32 mesh (0.5 mm) | - | No more than 20% |

Although the system will be designed for a nominal 20% of 32 mesh (0.5 mm) material, up to a maximum of 25% fines, the retort will operate with feed shale at above 25% fines.

Oil shale will be reclaimed from the ROM-shale stockpile with front-end loaders and then fed to one or both feed hoppers. The feed hoppers are each equipped with a grizzly screen to control the size of shale and allow only minus 24" lumps to pass through to the hopper. A remote controlled lump breaker with positioning booms is used to break the oversized shale. From

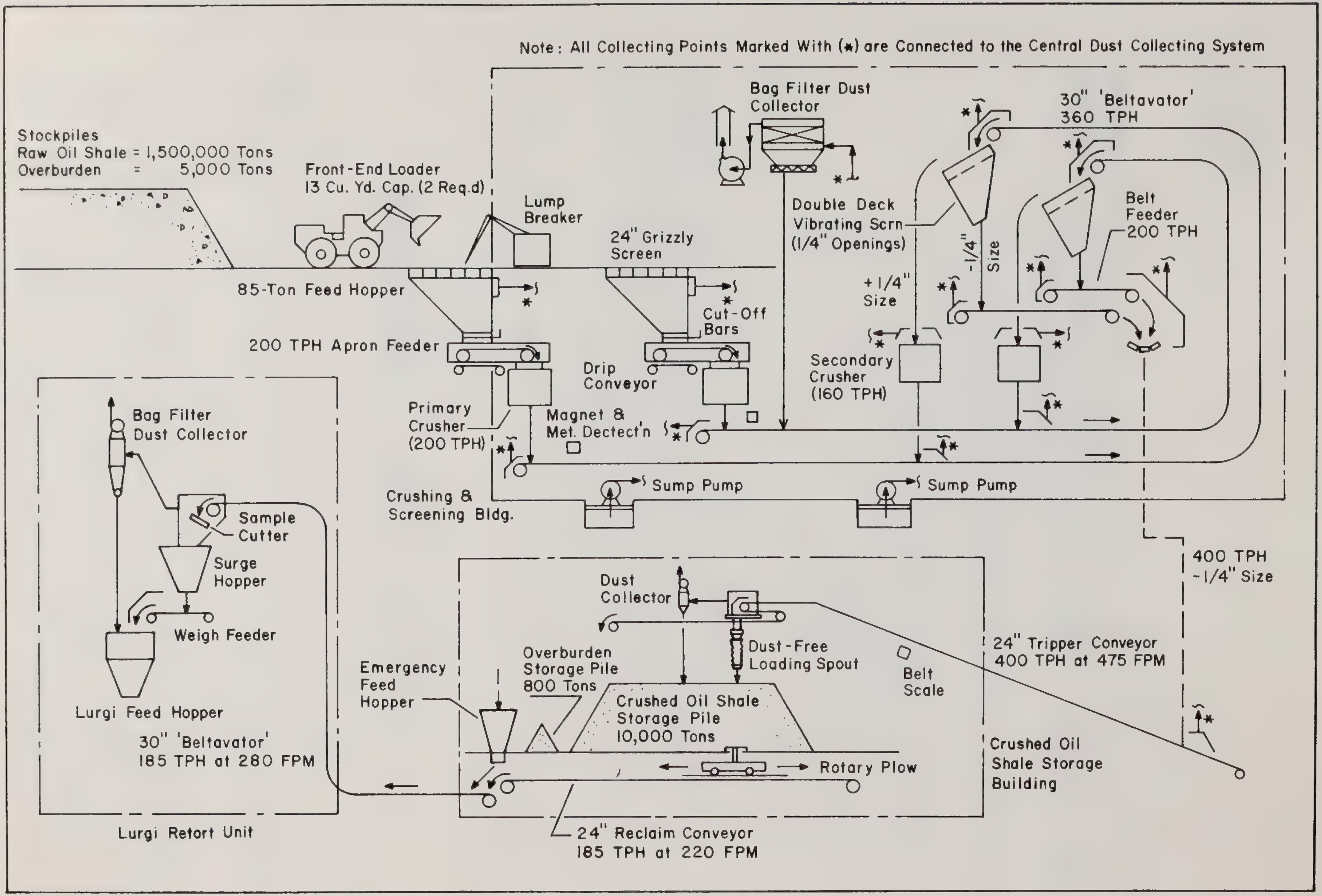



**Figure 3-1-1**
**Schematic Flow Diagram - Retort Feed Shale Preparation**

these hoppers, the shale will be fed by apron feeders to primary crushers where it will be crushed to minus 3" size and discharged to belt conveyors (Beltavators). The Beltavators will feed the crushed shale to two double-deck vibrating screens which are arranged in parallel. The oversize material from the screens will feed secondary crushers by way of chutes, and the undersize material (crushed product) will be conveyed to the storage building. The Beltavators will collect materials discharged from both primary and secondary crushers and deliver them to the vibrating screens in closed circuit.

The undersize material from the two vibrating screens is then delivered to a storage building by way of an overhead tripper conveyor, and stored in a stockpile. A rotary-plow type feeder is used to reclaim the material from the stockpile and to feed it to the Lurgi retort unit at a controlled rate.

During startup operation of the Lurgi retort unit, crushed overburden and supplementary fuel will be used in lieu of crushed shale. Crushed shale will be fed to the retort unit after the crushed overburden in the retort has reached the desired operating temperature.

The retort feed preparation system also provides the capability of producing crushed overburden for Lurgi retort start-up.

An emergency feed hopper is provided in the system for feeding material to the retort by a front-end loader in the event of retort feeding system stoppages or reclaimer problems.

## CHAPTER 2
## EMISSION CONTROL

This chapter describes specific dust control equipment associated with the Retort Feed Oil Shale Preparation System. See Section 7, Chapter 5 for detailed description on air quality control considerations.

### 2.1 DUST CONTROL FOR EQUIPMENT AND OPERATION

The main concern of air emission due to retort feed preparation is the fugitive dust of crushed oil shale produced during reclaiming from the stockpile, crushing, screening, conveying, stockpiling, and various intermediate oil shale handling operations.

Dust collection equipment is provided in the system. Dust-laden air is collected from all transfer points, screens, crushers and discharge chutes. The dust-laden air is then passed through the bag filter type dust collectors and cleaned air is exhausted to the atmosphere.

The dust collection system uses multi-compartment filters to collect the dust from the following points:

- Inlet and discharge from primary crushers
- Inlet and discharge from secondary crushers
- Discharge from main conveyor
- Discharge from two vibrating screens (undersize recovery discharge)
- Discharge from bag house dust return
- Discharge from Beltavator to Lurgi retort feed

Fines collected from the baghouse filters will be discharged to the tripper conveyer, combining with the crushed shale conveying to the storage pile.

The design of the dust control system will comply with the air volume requirements of the American Conference of Governmental Industrial Hygienists.

## 2.2 DUST CONTROL FOR CRUSHED SHALE STORAGE BUILDING

Roof ventilators for the crushed shale storage building are provided with air filters to control fugitive dust emission to the atmosphere from the building. These filters are of the disposable type. They will be replaced at regular intervals to assure the effectiveness of dust control and proper building ventilation.

## 3.1 RAW OIL SHALE RECLAIMING

Two front-end loaders are used to reclaim ROM shale from stockpiles and to feed it to the feed hoppers. The bucket size of each loader is approximately 12-13 cu. yd. and each can load 400 tons per hour ROM shale to the hopper at an average cycle time of 2.4 minutes.

The front-end loader is used because of its versatility and mobility, which allows it to perform a variety of tasks and to effectively move material in load-and-carry operations. When hauling distance increases in the future, other types of mobile equipment must work along with the original ones in order to maintain the required cycle time.

## 3.2 PRIMARY AND SECONDARY CRUSHING

A. Feed to Primary Crushers - The feed system is designed to control the maximum lump size and maintain a constant flow rate of material feeding the primary crushers. A grizzly screen is provided to allow minus 24" lumps to pass through to each primary crusher. The oversize material will be reduced to minus 24" by lump breaker equipment operated by remote control. Apron feeders located below 100-ton feed hoppers will each feed 200 TPH of minus 24" shale to the primary crushers. A drip conveyor placed underneath each apron feeder is included to collect the materials that drip down from the apron feeder and return them to the crushing system.

B. Crushers - One circuit will consist of a primary impactor and secondary impactor crusher. The other circuit will be a primary roll and secondary cage mill impactor crusher.

The primary crushers are designed to reduce 24" ROM oil shale to minus 3". They will produce approximately 60% of minus 1/4" crushed oil shale. The remainder will range from 1/4" to minus 3".

The secondary crushers are designed to reduce 3" oil shale to minus ¼" and will produce approximately 63% of minus 1/4" size from the oil shale processed through them.

The total crushing system (the primary and secondary crushers combined) produces 100% minus 1/4" oil shale with a nominal of 20% minus 32 mesh fines, which meets the feed specification as stated in Chapter 1 of this section.

C. Conveying System - Beltavator units are used to collect material discharged from the drip conveyors, and primary and secondary crushers, and then transfer this material to the screens. These conveyors will be designed for handling approximately 360 TPH each of minus 3" material. A "C" path type Beltavator was selected because its layout is well suited to recirculating systems and has the following advantages:

- Elimination of high maintenance bucket elevators
- Elimination of "zig-zag patterns" or long inclined belt conveyors resulting in saving space and reducing transfer points
- Less dust - elevated material is trapped between the two belts

## 3.3 CRUSHED OIL SHALE SCREENING

Two double-deck screen units are provided to separate the crushed oil shale.

The crushed oil shale from the primary and secondary crushers are separated by the screens into two groups: One is the oversize group which will be recycled to the secondary crushers for further size reduction and the other is the undersize recovery group which is the finished product from the crushing system. That is, all the finished products from the crushing system must come from the undersize recovery of the screens to ensure the quality of material feed to the retort.

The two screen units will be arranged in parallel. Each unit will be sized to handle a feed rate of 375 TPH and produce 200 TPH of undersize recovery. The screens are sized for an efficiency of 90% undersize recovery.

The correctly-sized crushed oil shale from the undersize recovery of the screens will be collected and conveyed to the crushed oil shale storage pile inside the crushed oil shale storage building.

## 3.4 ENCLOSED CRUSHED OIL SHALE STORAGE PILE

The crushed oil shale is stored in the enclosed crushed oil shale storage building. A belt tripper is used to build a long wedge-shaped pile or a conical pile.

Dust generated from the free falling material will be a problem with the piles made by the traveling belt tripper. Therefore, a retractable loading and stacking spout connected to a bag type dust collector will be used at the tripper discharge, which places the spout and the area around the top of the pile under negative pressure. As a result, dust and displaced air are withdrawn back up through the spout to the dust evacuation system which eliminates dust exposure to the atmosphere.

The design of the crushed oil shale storage pile is based on the following requirements:

- Storage capacity - 10,000 tons (approximately two days supply to Lurgi retort)
- Feed rate to storage - 400 tons per hour, continuous operation, 10-12 hours per day
- The storage area will be ventilated to minimize dust and methane build-up, and the hazard of spontaneous combustion will be considered

## 3.5 CRUSHED OVERBURDEN STORAGE PILE FOR RETORT START-UP

Crushed overburden will be used for start-up of the Lurgi retort operation. It is stored in the enclosed building adjacent to the crushed oil shale storage pile.

The crushed overburden pile is a conical shaped pile with a minimum storage capacity of 800 tons.

## 3.6 CRUSHED OIL SHALE AND START-UP OVERBURDEN RECLAIMING

A rotary plow feeder moving along a long slot is used to reclaim the material from the storage pile and discharge it onto a collecting belt. A double shelf-single plow with drive-below-plow arrangement is provided (see Figure 3-3-1) to enlarge the effective slot outlet. The drive system of the plow rotor provides constant torque and variable speed. The drive system is also capable of absorbing shock loads.

For safety reasons the reclaiming tunnel will have two outlets, one of which also serves as a ventilation shaft to a fan which circulates fresh air through the installation.

The advantages of plow reclaiming systems are:

- No dust is generated in the building atmosphere
- The undercutting action of the rotary plow eliminates material bridging and rat-holing often experienced with other type bottom reclaims
- Only one plow is needed to reclaim the entire storage pile, instead of multiple fixed feeders.

The first in-first out reclaiming operation in the live storage area will reduce the hazard of spontaneous combustion in the crushed shale as mentioned in Part 3.4 of this chapter.

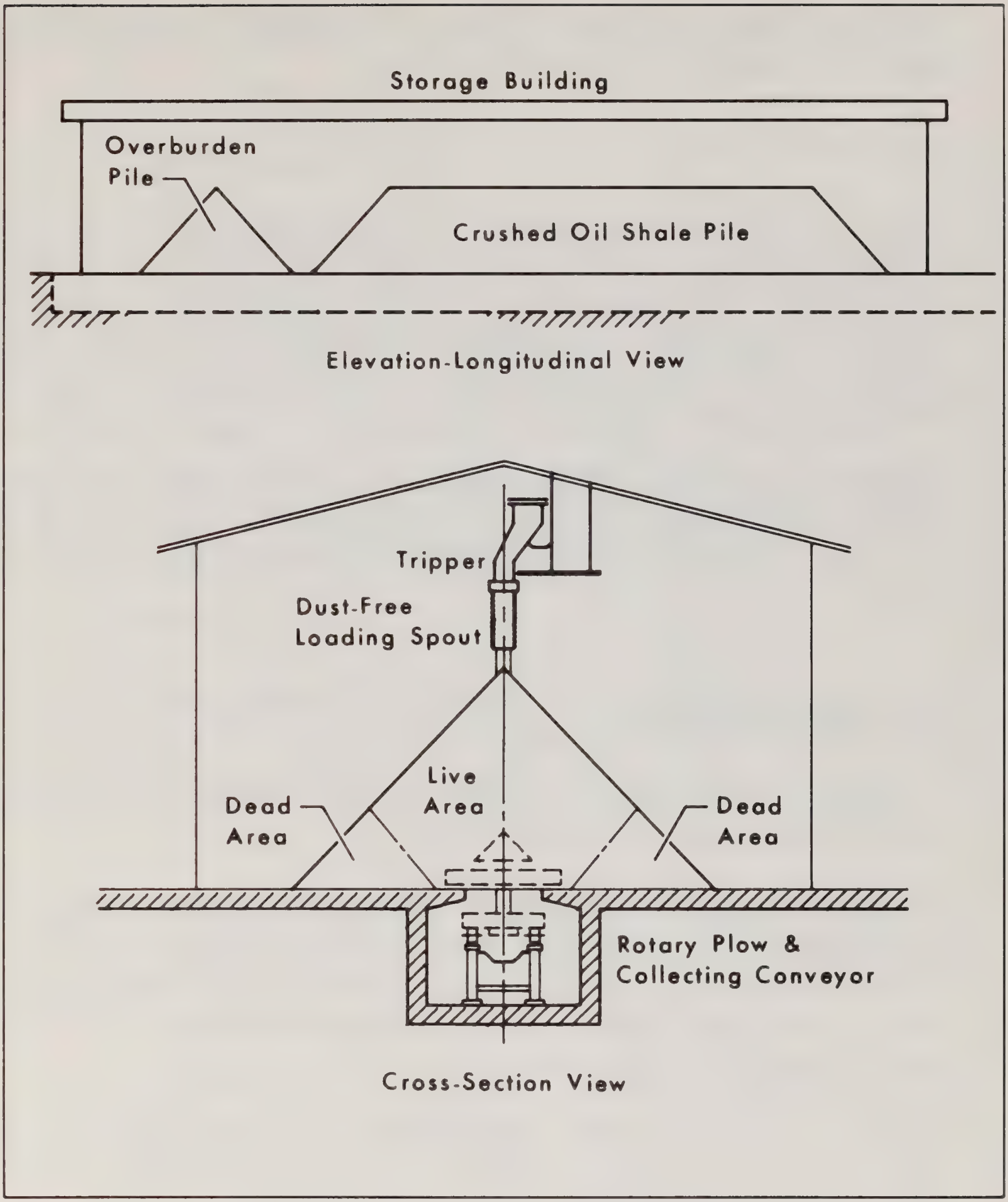



Figure 3-3-1
Crushed Oil Shale Storage Building Layout

A front-end loader or bulldozer will be required to move the material from the dead area of the piles to the live storage area.

## 3.7 RETORT FEED SYSTEM

Material reclaimed from the stockpile in the storage building is collected on the horizontal run of a "Z" path type Beltavator. The horizontal run of the Beltavator is located in the tunnel of the building and is extended to the Lurgi processing unit. The elevated portion of the Beltavator is located outside the Lurgi structure and extends to a surge hopper which is approximately 200 feet above ground.

The Beltavator will feed 185 TPH of material to the retort unit. The configuration of this type Beltavator is well suited to the layout of the equipment. It also has the advantages as described in Part 3.2.C of this section.

## 3.8 WEIGHING AND SAMPLING

A. Weighing - A belt scale is provided to weigh the crushed oil shale conveyed to the crushed oil shale storage pile.

A gravimetric weigh feeder is provided to weigh and to control the feed rate of the material to the retort. This is a totally enclosed unit and is designed to measure a fluctuating flow of material and make a permanent record of the flow. It can shut off all upstream equipment if the flow of material through the feeder should stop.

The storage inventory in the storage building can be recorded from the balance of weighing records of the belt scale (before storage) and gravimetric feeder (after storage).

B. Sampling - A sample cutter is provided at the discharge of the "Z" path type Beltavator at the retort feed. In sampling, material is collected by a sample cutter in controlled increments, and these increments are combined to make a gross sample. This gross sample will be sent to a laboratory where it will be reduced from a gross to a laboratory sample by specified procedures and analyzed for particle size distribution, moisture content, Fischer Assay and minerological content.

## 3.9 SIZE CONTROL OF CRUSHED OIL SHALE

The control of oversized oil shale is by further size reduction. Oversized (+1/4" size) oil shale will come off the top of the vibrating screens and then feed into the secondary crushers and is crushed again in closed circuit. The control of excess fines is an integral part of the design of the primary and secondary crushers. It lies in the selection of design size reductions through the crushers. The crushers are designed to produce minus 1/4" crushed shale with a nominal of 20% minus 32 mesh fines, which is acceptable as the Lurgi retort feed. Consequently, the generation of excess fines from the crushing operations should not present processing problems.

## 3.10 ALTERNATIVES

A. Single Circuit Crushing and Screening - The economics and system reliability of a single crushing and screening circuit are presently being evaluated as an alternative to the parallel crushing and screening circuit described.

B. Crushers - Evaluation of a primary gyratory crusher as an alternative to a primary roll crusher is underway. Crushing tests, capital and operating costs, and quality control of the product will determine final crusher selection.

C. Raw Shale Storage - Several alternatives are being considered for storage facilities for the raw shale feed material. A prime candidate is a slip-form concrete silo.

# Section 4

## LURGI PROCESSING

# CHAPTER 1
# INTRODUCTION

The first processing step in the conversion of oil shale to useful hydrocarbon energy involves heating the shale to a temperature of about 900°F. This heating process decomposes the high-molecular-weight solid organic material contained in the shale into smaller hydrocarbon molecules. Cooling and condensing the resulting vapors produces an oil product which resembles crude oil in several respects (such as boiling range and hydrogen to carbon ratio). This process of heating oil shale and decomposing the contained organic material (kerogen) is known as retorting.

This section describes the processing and support facilities for the Lurgi Demonstration Project, using Lurgi surface retort technology.

Proprietary data of the Lurgi retort process have been submitted to OSO separately.

## 1.1 RETORTING

Experimental research and development work on retorts has been underway in the United States since the 1920's. Industrial efforts in other countries date back to the 1850's. During the first 100 years emphasis was placed on the development of aboveground retorts, resulting in significant technological advances for this process. Recently, experimental work has also been directed toward methods of in situ retorting.

For the purpose of determining the feasibility of commercial production, both aboveground and MIS retorting technologies have been considered for development of Tract C-a. The following guidelines were used in choosing among the several developmental retort processes:

- The retorting process must be capable of continuous operation and give efficient recovery of energy from shale.

- The experimental work for such technology must be sufficiently far advanced to assure a reasonable chance of successful operation of a large scale, commercial-size retort.
- The retorting technology must be available to RBOSC either from information in the public domain or by license from "know-how" holders.
- The retorting process should have a high thermal efficiency.
- Shale fines should be able to be processed.
- Heat for retorting is supplied indirectly so the off-gas is not diluted with nitrogen.

Considering these factors, the Lurgi process was selected mainly because of anticipated high energy recovery, and its processing efficiency wherein the heat required for retorting is supplied from the residual carbon left in the processed shale after it has been retorted.

Parallel to the MIS technology demonstration presently in operation, the Lurgi Demonstration Project will demonstrate the Lurgi surface retort technology.

## 1.2 PRODUCT DISPOSITION

Shale oil produced from the Lurgi retort will be shipped from Tract C-a by tank trucks to a market (not yet determined). This production is relatively small and will not justify pipeline shipment. For the same reason, no upgrading or treatment of the raw shale oil is planned for the Lurgi Demonstration Project. Refer to Section 6, Chapter 4 for additional information.

## 1.3 ENVIRONMENTAL CONTROLS

In order to comply with all applicable State and Federal air quality requirements for the leasing program, the best available environmental control technology will be used in the processing and support facilities. The system proposed to accomplish gas purification and particulate emission control has been operated effectively in oil refinery applications. Operating experience with the shale oil facility will likely lead to improvements in these control devices - a tacit objective of the prototype leasing program. Specific details of processing emissions and effects on air quality are given in Chapter 3 of this section and Chapter 5 of Section 7.

The best available control technology will also be adopted for the collection and treatment of plant effluents. Wastewater streams will be segregated, collected, and treated according to their characteristics and the levels of treatment required. Clean storm water run-off will be segregated from the other plant effluents and discharged to the surface water drainage after proper sedimentation. Treatment of plant effluents is described in Chapter 3 in this Section. Additional information on water quality control is given in Section 7, Chapter 6.

## 2.1 PARAMETERS

The Lurgi Demonstration Project processing and support facilities are located north of Tract C-a, on RBOSC off-tract property adjacent to the tract boundary. A plot plan of the processing and support facilities was developed by considering the following key parameters:

- Selection of elevated topography to enhance dispersion of stack emissions
- Selection of relatively level terrain to minimize site preparation and terracing
- Location of the processing plant close to the processed shale disposal site to minimize processed shale transfer
- Reasonable proximity to the mine
- Location of processing and support facilities for ease of access to corridors and product shipping

Figure 4-2-1 is the overall plan showing the mine and mining support facilities, the haul road for transfer of the run-of-mine (ROM) oil shale to the raw oil shale stockpile, the Lurgi processing and support facilities, and the processed shale disposal areas.

## 2.2 LURGI PROCESSING AND SUPPORT FACILITIES

A plot plan depicting the arrangement of facilities for processing operation is shown in Figure 4-2-2.

The oil shale retort feed preparation area is located in the southwest portion of the plot, close to the raw oil shale stockpile. It is strategically located to minimize material handling for reclaiming the raw oil shale from stockpile for crushing and screening, and to feed the Lurgi retort in the adjacent area. The product gas cleaning and disposal system (incinerator

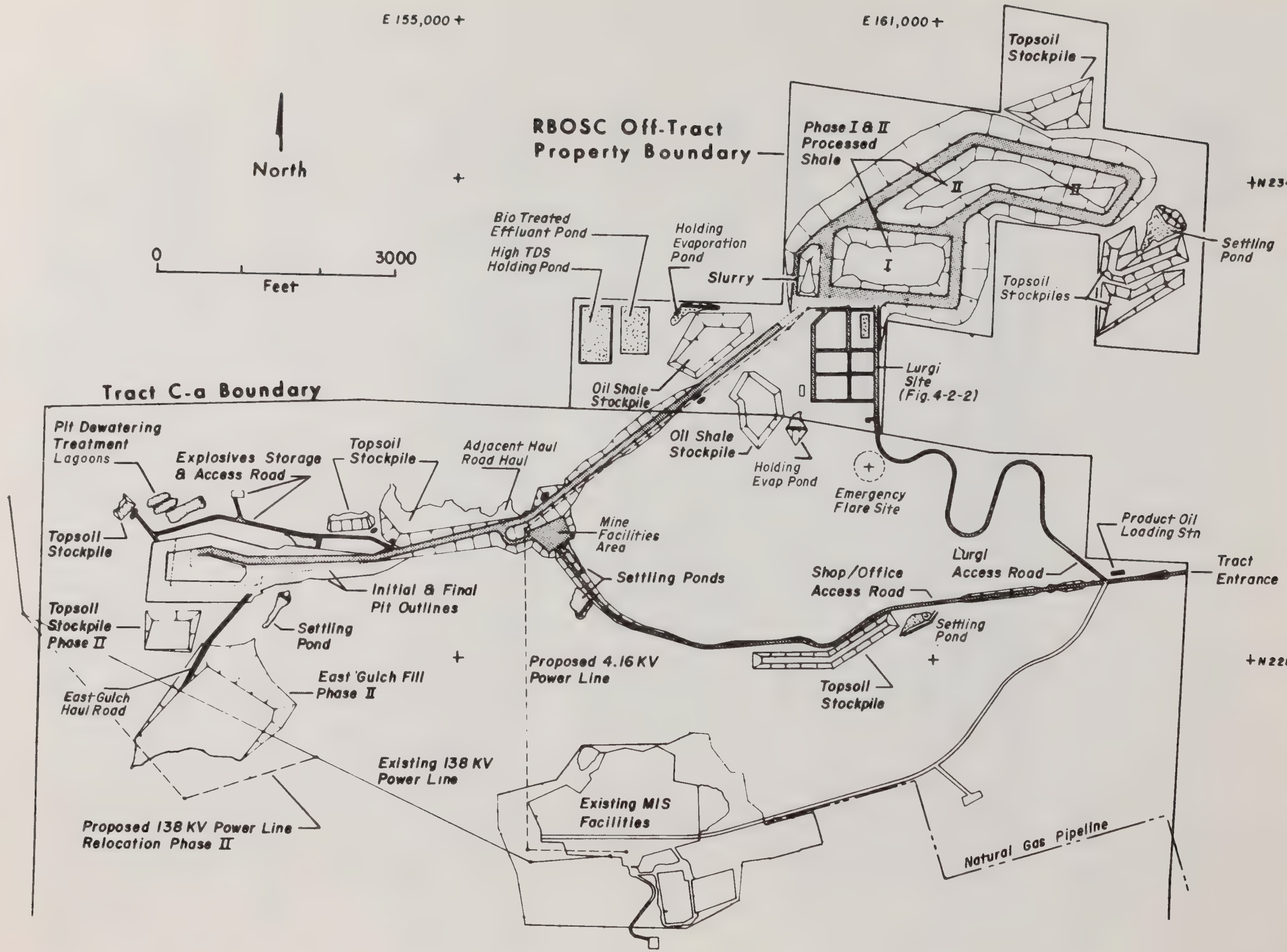



Figure 4-2-1
Lurgi Demonstration Project Plot Plan

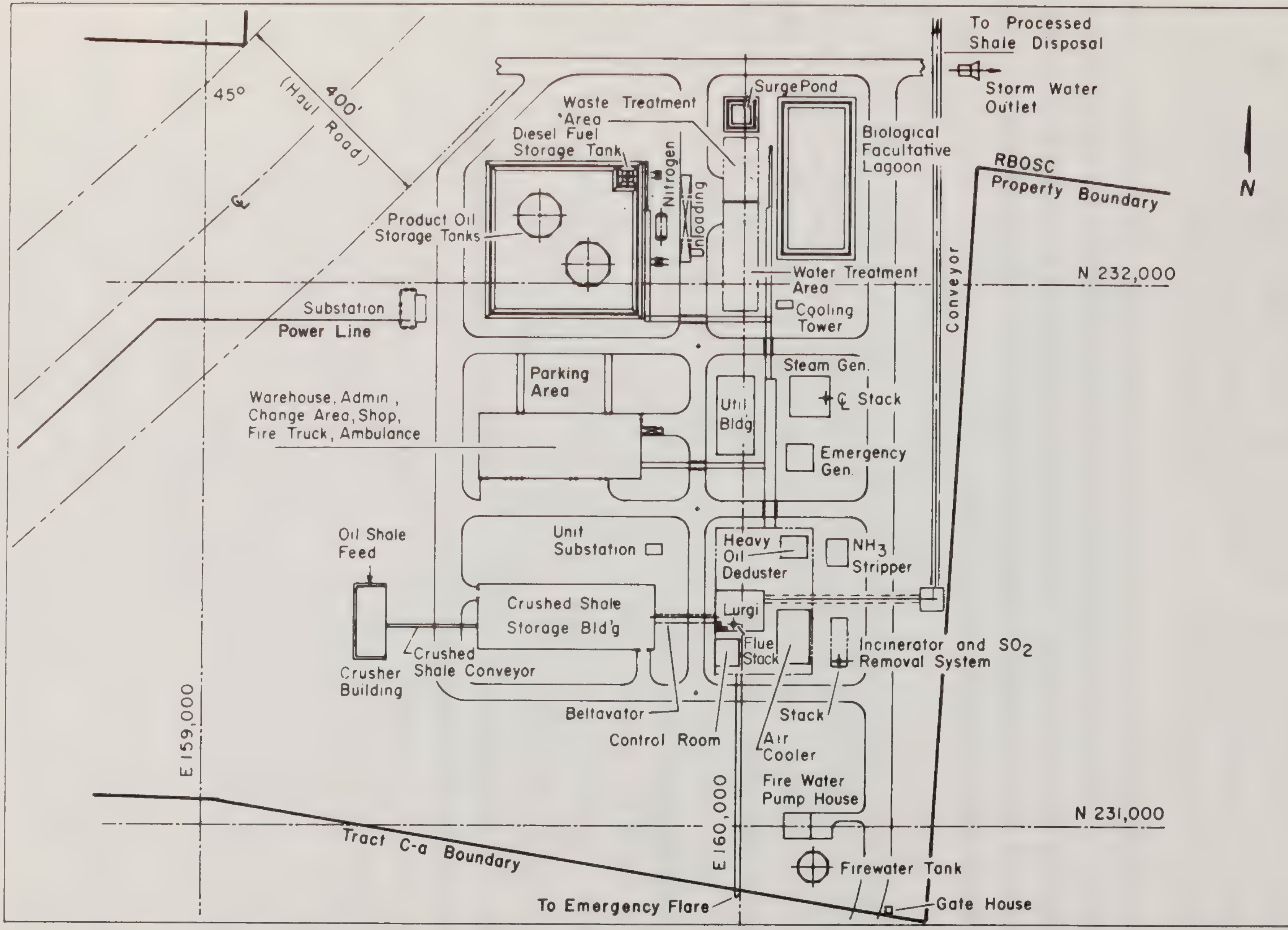



**Figure 4-2-2**
**Plot Plan-Lurgi Processing & Support Facilities**

and $SO_2$ scrubber) is located near the Lurgi retort for efficient system design and dispersion of flue gas. The utility, water, and waste treatment areas are located to the north of the feed shale preparation and Lurgi processing operations. The administration/warehouse/maintenance building is centrally located for easy access from all operating areas.

The emergency flare is located south of the Lurgi processing area. The product oil loading station is located off the access road to the Lurgi plant near the tract entrance. (Both are shown in Figure 4-2-1.) Product oil is piped from the processing area to the product oil storage tanks and from the storage tanks to the loading station.

The plot plan shown in Figure 4-2-2 depicts the present concept for the layout of the Lurgi Demonstration Project processing and support facilities. This plan is preliminary and may change as detailed engineering proceeds. It is expected that the changes will be refinement in nature and will not alter the basic concept presented at this time.

## 2.3 STACK LOCATIONS

Major atmospheric emission points, such as the Lurgi retort, product gas incinerator and $SO_2$ removal system, and the steam generator stack are shown in Figure 4-2-2. The emergency flare is shown in Figure 4-2-1. See Section 7, Chapter 5 for detailed descriptions of the emission points and air quality control considerations.

## 3.1 PROCESS DESCRIPTION

The Lurgi (L-R) Oil Shale Process has been developed and patented by Lurgi Kohle Und Mineraloltechnik GmbH. During the past 30 years the basic process has been successfully applied in the steel, chemical and oil refining industries to produce a variety of fuels and chemicals products. The use of the Lurgi Oil Shale Process on Tract C-a, however, will be its first application to oil shale in the United States.

The 4,400 TPSD retort has been designed to process oil shale ranging from 15 to 35 gpt Fischer Assay. Process data presented herein are based on 23 gpt oil shale. The major components of the Lurgi Oil Shale Process, i.e. all items shown on Figure 4-3-1 except items 8, 10, 11 and 12, will be built into the 70 feet by 90 feet by 285 feet high Lurgi tower structure. This tower will be surrounded by auxiliary facilities, the heavy oil dedusting unit and the control house, as shown on the plot plan, Figure 4-2-2. The main processing block will cover about 1.5 acres.

Of course, the primary product from the Lurgi retort will be raw shale oil. As designed, 92.5% Fischer Assay oil will be recovered as liquid. Yield would be 100% of Fischer Assay if pentane and heavier components were recovered from the product gas. Recovery of these components is not economically viable in the demonstration plant. In addition, the processing facilities will produce a high btu product gas (980 Btu/SCF), high pressure steam (565 psig, saturated) and water. As is true for all oil shale processes, this water product will have to be further treated before it can be used. Finally, two waste products, flue gas and processed shale, will also be produced in the Lurgi Oil Shale Process.

Included along with the process description are the schematic flow diagrams and tables of material balances and product qualities. Additional information regarding product gas and effluent treatment, processed shale disposal and environmental control are found in Sections 5 and 7.

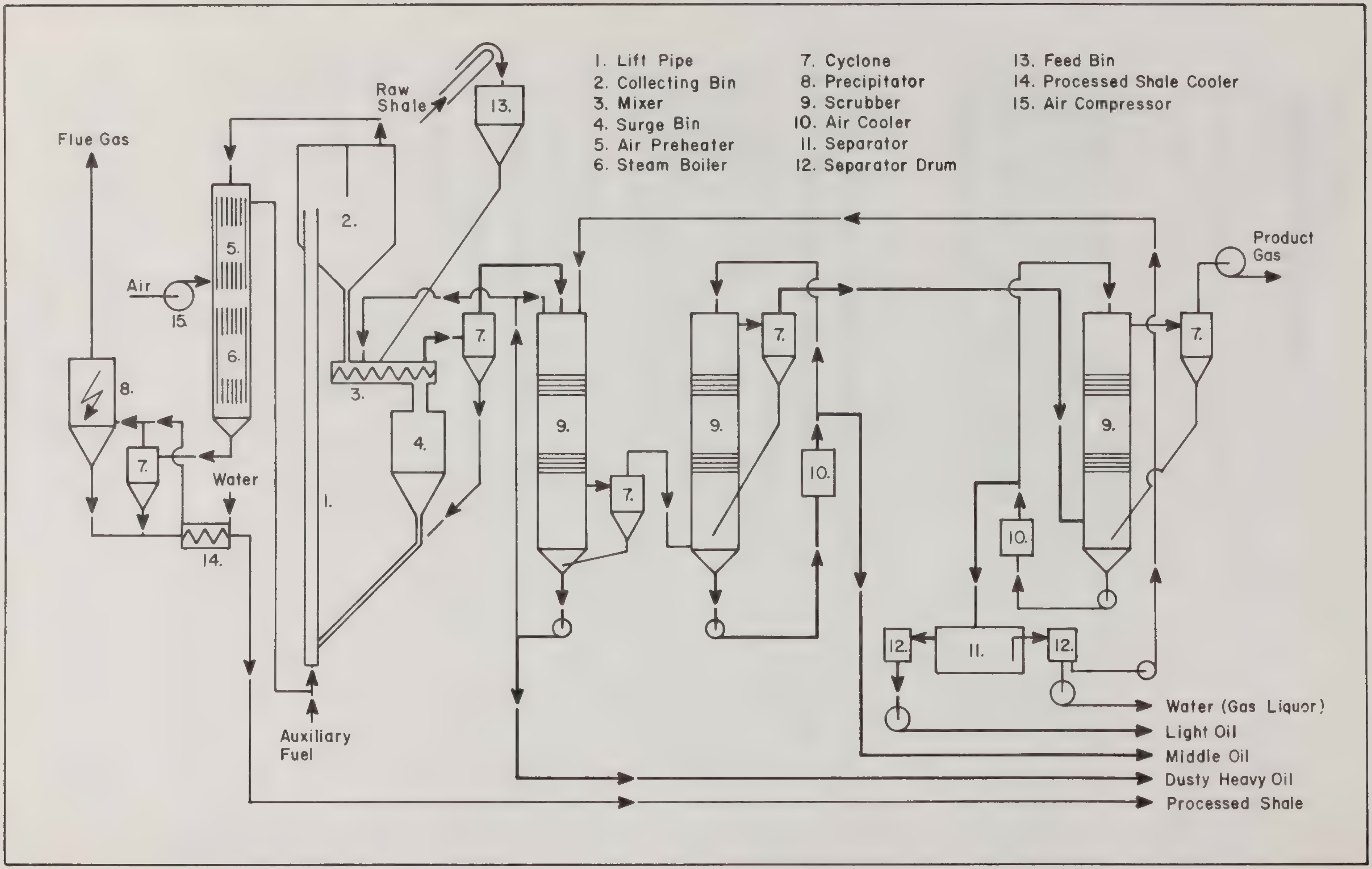



**Figure 4-3-1**
**Schematic Flow Diagram–Lurgi-Ruhrgas Oil Shale Retort**

A. Lurgi Retort - The heart of the Lurgi Oil Shale Process is the "Lurgi Loop" located in the Lurgi tower. It consists of the feed bin, the Lurgi mixer, the surge bin, the lift pipe and the collecting bin, along with associated piping and other transfer lines. A schematic diagram of this Lurgi loop is shown in Figure 4-3-1.

Raw oil shale feed of 4,400 TPSD of minus 1/4 inch size will be received at the top of the Lurgi tower for transfer to the feed bin. It will be conveyed to that point from the crushed shale storage pile by the belt conveyors discussed in Section 3. This amounts to 100% of mined and crushed shale, thus no rejection of fines is required. At the transfer points at the top of the Lurgi tower, dust emissions will be controlled through the bag house filter system, as shown in Figure 3-1-1.

From the feed bin, raw oil shale is transferred to the mixer, where it is mixed with hot, recycle, processed shale. The temperature of this recycle, processed shale will be over 1,200°F., so that, during mixing, the raw shale temperature will be increased to the pyrolysis temperature of 900 to 1,000°F. Hydrocarbon vapors and water vapor, the products of the retorting process, will pass through two cyclones after leaving the mixer towards the condensation unit. At the same time, the mixture of solids will fall into the surge bin.

From the surge bin the mixture of processed shale will fall into the bottom of the Lurgi lift pipe, where hot air at about 840°F and auxiliary fuel will be added. During the operation of the demonstration unit, various fuels such as natural gas, product gas and retort oil will be considered as auxiliary fuel. Product gas is the preferred auxiliary fuel and the others will be used for start-up or demonstration purposes. As the gas lifts the processed shale from the bottom of the lift pipe to the top, the residual carbon on the "fresh" processed shale and the auxiliary fuel will be burned, raising the temperature of the combined gas - solids mixture to approximately 1,200°F.

As this stream reaches the collecting bin, its flow velocity is reduced, so that the required amount of recycle processed shale can fall to the bottom of the collecting bin, thereby completing the Lurgi loop. The lift pipe flue gas, containing a part of the burned processed shale, will continue out of the top of the collecting bin towards the heat recovery section. The balance will be discharged directly from the collecting bin to the processed shale cooler.

B. Heat Recovery/Processed Shale Cooling - The purposes of this part of the Lurgi Oil Shale Process are to recover energy from the hot flue gas and processed shale, to remove processed shale particles from the flue gas and to cool the processed shale before it is transferred to the disposal area. This part of the process is also shown schematically on Figure 4-3-1.

From the top of the collecting bin, the flue gas/processed shale mixture will flow first through the air preheater, then through the steam generator. In the air preheater, fresh combustion air will be pre-heated before being introduced into the bottom of the Lurgi lift pipe. As its name implies, the steam generator will recover heat from the flue gas/processed shale stream to produce high pressure, high temperature steam.

Again because of the reduced flow velocities, some of the processed shale particles will be separated from the flue gas stream in the steam generator. These processed shale particles will go directly to the processed shale cooler. The gas and remaining processed shale particles will leave the steam generator, pass through a cyclone and then through an electrostatic precipitator to remove particulates before being emitted to the atmosphere through the stack. The processed shale particles removed from the flue gas in the final flue gas cyclone will also go from the cyclone to the processed shale cooler.

In the processed shale cooler, the evaporation of water will be used to cool processed shale to approximately 200°F. The processed shale will be discharged from the processed shale cooler onto a processed shale moisturizer. Any dust generated at this point will be controlled through the use of a bag house filter, as shown in Figure 4-3-6.

The water vapor created inside the processed shale cooler will be withdrawn under slight vacuum from the cooler and mixed with the flue gas at the inlet of the electrostatic precipitator which has a recovery-efficiency of greater than 99.9%. The presence of the water vapor in the flue gas/processed shale mixture will improve the recovery efficiency of the electrostatic precipitator. In that facility, the remaining processed shale particles will be removed from the flue gas, so that the stack emissions contain only trace amounts of processed shale dust. The dust which is removed will also be transferred back to the processed shale cooler for final cooling before disposal.

The composition of the flue gas is described in Table 4-3-1 and discussed further in Section 7, Chapter 5. Disposal of the processed shale, which should contain less than 0.3 weight percent carbon, is further discussed in Sections 5, Chapter 2 and Section 7, Chapter 8.

C. Oil Condensation - The purpose of the final portion of the L-R Oil Shale Process is to recover the raw shale oil as a liquid from the distillation gas from the Lurgi mixer. As shown in Figure 4-3-1, this part of the plant consists of three condensation/scrubber towers. In the first of these towers, the highest boiling fraction of the raw shale oil is condensed by recycle water evaporation. The heavy oil produced at the bottom of this tower will also contain the fine particles of processed shale which are carried over from the Lurgi mixer to the oil condensation section.

In the second and third condensation/scrubber towers, the shale oil is condensed into two further fractions, the middle oil and the light oil. The retort water (gas liquor) is also condensed in the third scrubber. These condensation steps have been selected so that the light oil and gas liquor can easily be separated from each other in a gravity settling vessel.

In this portion of the Lurgi Oil Shale Process, heat removal for condensation will be achieved almost entirely through the use of fan-driven air coolers. RBOSC plans in this way to develop additional information on the usefulness of air coolers in the difficult climatic conditions expected during the winter at Tract C-a.

Table 4-3-1

LURGI FLUE GAS COMPOSITION*

(Flow is 266,500 lb/hr at 460°F)

| | | Vol% |
|---|---|---|
| water | | 26 |
| $CO_2$ | | 12 |
| $N_2$ | | 57 |
| $O_2$ | | 5 |
| | TOTAL | 100 |
| $SO_2$ | | 30 ppm |
| $H_2S$ | | not detected |
| $NO_x$ | | 300 ppm |
| $CH_4$ | | .15 |
| $NH_3$ | | .2 |
| CO | | 90 ppm |
| $H_2$ | | .2 |
| dust | | 0.0784 grains/SCF |
| | | 0.0346 grains/ACF |

* Derived from pilot plant test data

The products of the oil condensation section will be a dusty heavy oil fraction, a middle oil fraction, a light oil fraction, the gas liquor and a product gas. The qualities of these streams are contained in Tables 4-3-2, 4-3-3 and 4-3-4 respectively, and will have the following disposition:

- The dusty heavy oil will be transferred to the heavy oil dedusting section for further treating.
- The middle oil and light oil will be transferred to oil storage tanks described in Section 6.
- Dedusted heavy oil, middle oil and light oil will be stored in common tanks.
- The net gas liquor will be transferred to the waste treating facilities as described Part 3.3.G of this Chapter.

Table 4-3-2

PRODUCT OIL QUALITIES*

| Heavy Oil (dust free) | | Middle Oil | |
|---|---|---|---|
| Density (60°F) | 61.3 pcf | Density (60°F) | 56.8 pcf |
| Viscosity (60°F) | 700 cp | Viscosity (60°F) | 10 cp |
| Conradson test | 5.3 wt.% | | |
| true boiling points | ASTM-D 86 | true boiling points | ASTM-D 86 |
| IP Vol.% | 358.9 °F | IP Vol.% | 267.8 °F |
| 5 " | 365.0 °F | 5 " | 381.2 °F |
| 10 " | 378.9 °F | 10 " | 411.8 °F |
| 30 " | 788.7 °F | 30 " | 521.6 °F |
| 50 " | 843.9 °F | 50 " | 611.6 °F |
| 70 " | 879.9 °F | 70 " | 708.8 °F |
| 90 " | 902.8 °F | 90 " | 829.4 °F |
| 95 " | 902.8 °F | 95 " | 869.0 °F |
| FP | 902.8 °F | FP | 919.4 °F |

| Light Oil | | |
|---|---|---|
| Density (60°F) | Fract. I | 54.0 pcf |
| | Fract. II | 54.8 pcf |
| Viscosity (60°F) | | 3.7 cp |

| | | Fract. I | Fract. II |
|---|---|---|---|
| true boiling points | | ASTM-D 86 | ASTM-D 86 |
| IP | Vol. % | 28.4 °F | 287.8 °F |
| 5 | " | 188.6 °F | 297.1 °F |
| 10 | " | 212.0 °F | 307.2 °F |
| 30 | " | 289.4 °F | 332.6 °F |
| 50 | " | 325.4 °F | 360.0 °F |
| 70 | " | 368.6 °F | 391.0 °F |
| 90 | " | 431.6 °F | 455.2 °F |
| 95 | " | 469.4 °F | 486.5 °F |
| FP | | 512.6 °F | 511.5 °F |

* Derived from pilot plant test data

Table 4-3-3

GAS LIQUOR QUALITY*

| | |
|---|---|
| pH-value | 9.2 |
| oil content | traces |
| phenols | 225 mg/l |
| ammonia free | 6.0 g/l |
| ammonia fix | 0.4 g/l |
| total sulfur | 0.22 g/l |
| fatty acids | 580 mg/l |

* Derived from pilot plant test data

Table 4-3-4

PRODUCT GAS QUALITY*

| | |
|---|---|
| Density | 0.0726 lb/SCF |
| Net calorific value | 980 Btu/SCF |
| water | 4.3 vol.% |
| $CO_2$ | 24.0 vol.% |
| $H_2$ | 27.3 vol.% |
| CO | 2.8 vol.% |
| $N_2$ | 2.8 vol.% |
| $CH_4$ | 13.0 vol.% |
| $C_2H_4$ | 4.8 vol.% |
| $C_2H_6$ | 4.6 vol.% |
| $C_3H_6$ | 4.1 vol.% |
| $C_3H_8$ | 2.1 vol.% |
| $i\text{-}C_4H_{10}/n\text{-}C_4H_{10}$ | 0.8 vol.% |
| $C_4H_8$ | 2.7 vol.% |
| $C_5H_{12}$ | 1.8 vol.% |
| $C_6H_{14}$ | 1.1 vol.% |
| $C_6H_6$ | 0.1 vol.% |
| $C_7H_{16}$ | 0.3 vol.% |
| nbp degree F | |
| 64 thru 259 | 2.9 vol.% |
| 259 thru 617 | 1,264 ppm vol. |
| 617 thru final | traces |
| $H_2S$ | 3860 ppm vol. |
| $SO_2$ | 56 ppm vol. |
| $NH_3$ | 323 ppm vol. |

* Derived from pilot plant test data

- The product gas will go by pipeline to the gas treating facilities, although a portion of it will be used as auxiliary fuel in the Lurgi lift pipe and as purge gas.

D. Heavy Oil Dedusting - In the Lurgi retorting process some of the fine dust leaves the retorting section (screw mixer and surge bin) and is recovered with the highest boiling portion of the raw shale oil (referred to in this section as heavy oil). The solids concentration of the heavy oil will be controlled during operation to be in the range of 25-40% by changing the operating conditions. For example, if the solids concentration should be higher than desired, the first scrubber temperature will be reduced slightly to condense additional oil thereby diluting the dust in the heavy oil stream. The dedusting of the heavy oil is accomplished in a manner which will discharge nothing to the environment, and all streams which do not become the raw shale oil product will be recycled back to the retort section. The primary unit operations used in this section are centrifugation, drying, and stabilization.

The heavy oil from the retort will be centrifuged to recover a solid phase containing some residual heavy oil and a centrate which would flow to product storage or distillation, should it be desireable to recover some of the lower boiling portions of the raw shale oil which is present. The solid phase will be reslurried with a low boiling portion of the raw shale oil, after it has been stabilized to remove any low boiling components (butane and lighter for example). This solid will then be centrifuged again to produce a solid phase which now contains much less heavy oil and predominantly the lower boiling components of raw shale oil. This solid phase is moved to an indirectly heated dryer where the light oils are recovered and condensed and either sent to product or recycled with the heavy oil dedusting unit.

The solid phase from the indirect dryer now contains a small enough portion of heavy oil that it is no longer tacky. This material is then transported pneumatically back to the oil shale retort and injected into the lift pipe where the heavy oil is consumed as fuel in order to help heat balance the retort. As a result, this processed shale also is very low in organic content and will be discarded with the processed shale from the shale cooler.

As mentioned before, the lighter fraction of the raw shale oil will be stabilized so that vapor pressures are not excessive in the heavy oil dedusting section. This material is recycled back to the condensation stage where it will join the product gas and handled with the product gas produced in the shale retort.

Figure 4-3-2 is a block flow diagram of the heavy oil dedusting scheme.

E. Material Balances - The overall material balance for the Lurgi shale process, based on using product gas as auxiliary fuel and including the heavy oil dedusting process, is shown on Table 4-3-5.

Shown on Tables 4-3-6, 4-3-7 and 4-3-8 are process consumptive water usage and Lurgi retort sulphur and organic nitrogen balances.

Table 4-3-5

LURGI RETORT MATERIAL BALANCE[1/]

| Input | lb/ton feed | Nominal Rates |
|---|---|---|
| Fresh shale feed | 2,000 | 4,400 ton/stream day |
| Air | 1,097 | 43,750 scfm |
| Make-up water | 200 | 73.4 gal/min. |
| | 3,297 | |
| **Output** | | |
| Product gas (net)[2/] | 30 | 1,200 scfm |
| Gas liquor (sour water)(net)[3/] | 60 | 22.0 gal/min. |
| Raw shale oil | 160 | 2,230 barrel/stream day |
| Flue gas | 1,451 | 61,020 scfm |
| Processed shale | 1,596 | 3,511 ton/stream day |
| | 3,297 | |

1/ Derived from pilot plant test data

2/ Total product gas minus the product gas used as auxiliary fuel

3/ Gas liquor discharged from processing unit minus evaporator concentrate recycled to process

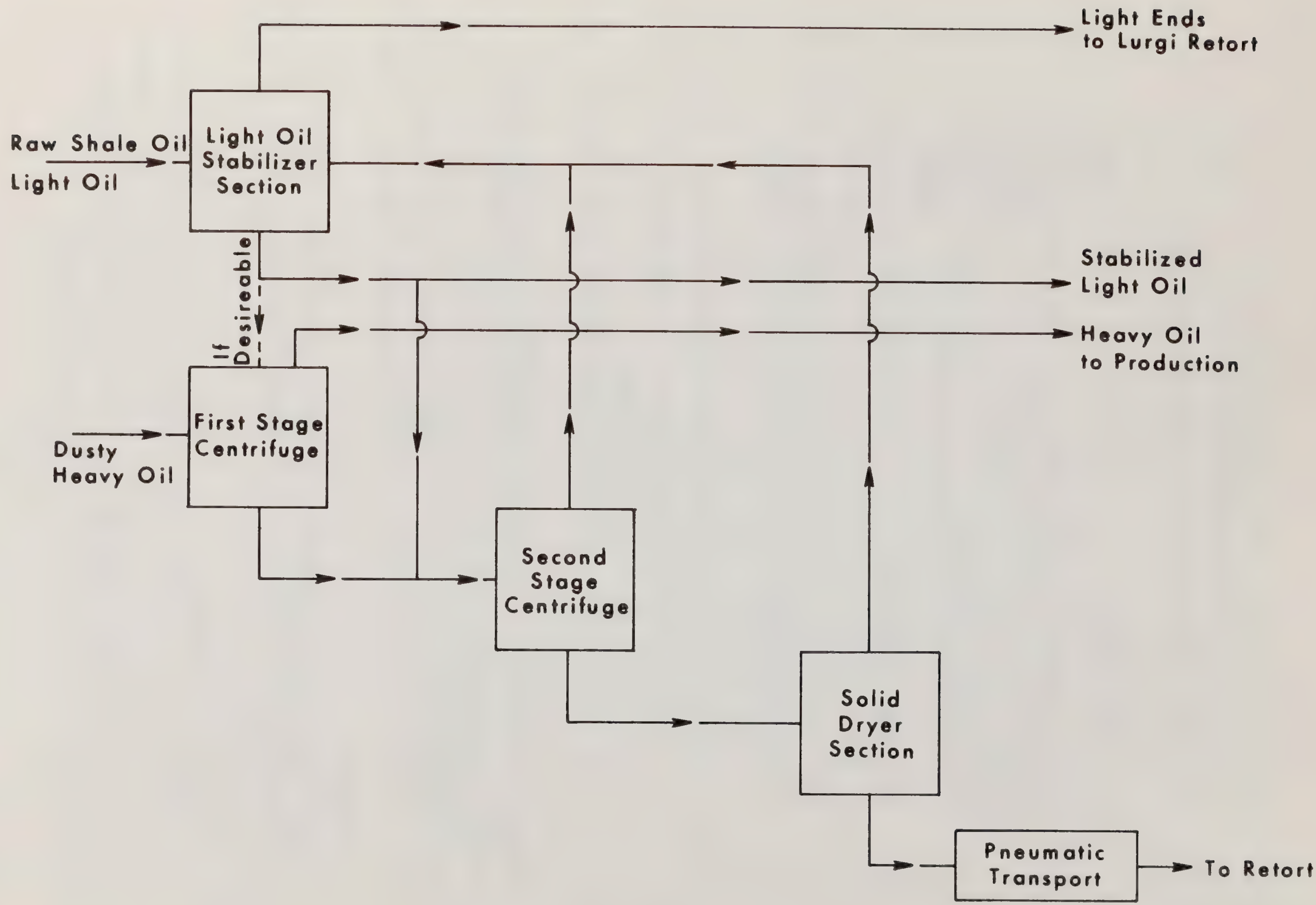



Figure 4-3-2
Block Flow Diagram - Heavy Oil Dedusting

Table 4-3-6

LURGI PROCESS FACILITY CONSUMPTIVE WATER USE

| Use | gpd |
|---|---|
| Incinerator/scrubber evaporation | 176,400 |
| Processed shale moisturizing (17.5%)* | 147,600 |
| Processed shale cooling evaporation | 102,200 |
| Steam system losses | 48,100 |
| Cooling tower evaporation | 24,500 |
| Pond and facultative lagoon evaporation | 10,000 |
| | 508,800 |
| Net process condensate | (31,700) |
| TOTAL | 477,100 |

* Does not include water for processed shale test program and dust control - See Table 5-2-3

Table 4-3-7

SULPHUR BALANCE*

| Feed | lb/ton feed sulphur as S | % organic S |
|---|---|---|
| Fresh shale feed | | |
| - organic S | 5.5 | 100 |
| - mineral S | 14.5 | |
| | 20.0 | |
| Products | | |
| Flue gas | 0.05 | 0.9 |
| Gas liquor (sour water) | $1.3 \times 10^{-5}$ | 0.02 |
| Product gas | 0.14 | 2.5 |
| Raw shale oil | 1.4 | 25.5 |
| Processed shale | | |
| - organic S (as $Ca/MgSO_4$) | 3.91 | 71.1 |
| - mineral S | 14.5 | |
| | 20.0 | 100.0 |

* Derived from pilot plant test data

Table 4-3-8

ORGANIC NITROGEN BALANCE*

| | lb/ton feed |
|---|---|
| **Feed** | |
| Fresh shale feed | 8.105 |
| | |
| **Products** | |
| Flue gas - reduced to $N_2$ | 2.7 |
| Flue gas - As $NO_x$ | 0.3 |
| Gas liquor (sour water) | 0.3 |
| Product gas | 0.005 |
| Raw shale oil | 3.2 |
| Processed shale | 1.6 |
| | 8.105 |

* Derived from pilot plant test data

3.2 LURGI PROCESSING EMISSIONS AND CONTROL

A. Atmospheric Emissions - Three possible sources of atmospheric emissions can be found in the processing facility. These are fugitive dust at conveyor transfer points, emissions from storage tanks and emissions in the Lurgi flue gas. Process design conditions will be discussed here. See Section 7, Chapter 5 for details of emission control.

Fugitive dust emissions at transfer points on conveyors in the Lurgi processing area will be controlled by means of the bag-house filter system. This system is described in Section 3.

Possible hydrocarbon emissions from tankage and other places in the processing facility will be controlled by condensation temperatures in the condensation section and the heavy oil dedusting section. Qualities of product oils, gas liquor and product gas are shown on Tables 4-3-2, 4-3-3 and 4-3-4.

The composition of the Lurgi flue gas is shown on Table 4-3-1. This stream is expected to be the major emission source in the Lurgi Oil Shale Process. It is expected to contain small concentrations of sulphur dioxide, carbon monoxide, processed shale dust and other elements.

The emission of sulphur compounds is reduced to a low level in the Lurgi Oil Shale Process because of the decomposition of dolomite and calcite in the Lurgi lift pipe. The decomposition products are calcium oxide and magnesium oxide, both of which react with $SO_2$ to produce solid salts. Tests have shown that substantial quantities of the carbonates fed with the oil shale into the Lurgi process will decompose into their oxides which will give more than enough metal oxides for sufficient $SO_2$ absorbtion. These salts will remain in the processed shale by-product from the process. Thus, the $SO_2$ concentration in the Lurgi flue gas will be reduced to 30 ppm by volume. The impact of this emission is further discussed in Section 7, Chapter 5.

The sulphur balance in Table 4-3-7 also includes the sulphur from the product gas used as auxiliary fuel. Even if sulphur from pyrite increases due to variations of the resource, the $SO_2$ concentration in the flue gas will still remain low because of excess metal oxides.

Experiments have shown that the production of carbon monoxide in the Lurgi process is related to the completeness of combustion in the Lurgi lift pipe. The data indicates that CO emissions can be reduced to less than 90 ppm by volume of Lurgi flue gas.

As discussed above in the process description, processed shale dust is removed from the flue gas using cyclones and an electrostatic precipitator. As shown on Table 4-3-1, dust emissions in the Lurgi flue gas are expected to be 0.0784 grains per SCF, equivalent to about 41 pounds per hour.

The emission of particulates in the flue gas is discussed in Section 7, Chapter 5.

B. Aqueous Effluent - Besides the gas liquor (process condensate) as stated in Part 3.1C of this chapter, there will be area washdown water and rain water runoff from the processing area. Catch basins and underground piping collection system (oily sewer) will be provided to collect and convey these waste water streams to the surge pond and to the waste treatment system.

Oil drains from equipment will be collected by a separate collection system for which a corrugated plate interceptor (CPI) oil separator will be provided. Water separated by the separator will be discharged to the oily sewer and treated with the area washdown water as discussed above, while the decanted oil will be recycled back to the process or sent to product storage.

A flushing water system will be provided for the Lurgi retort. It will be a closed system, consisting of two flushing water basins, pumps, and necessary piping. Make-up water may be necessary to compensate for evaporation loss. While one basin is used for flushing the retort after it is shut down and sufficiently cooled, the other is used for settling out processed shale flushed out from the retort during the previous flushing operation.

The flushing water should not contain any hydrocarbon as it will contact only processed shale in the flushing operation. There will be no discharge from the flushing water system. However, overflow to the oily sewer will be provided for each basin for emergency (such as maloperation of make-up water system) backup.

Solids accumulated in the flushing basins, i.e. processed shale, will be removed from the basins periodically and disposed of with the processed shale during normal plant operation.

### 3.3 DESCRIPTION OF SUPPORT SYSTEMS

A. Water Supply and Treatment - The Lurgi Demonstration Plant raw water supply will come from water supply wells in the Upper Aquifer. Supplemental water will be delivered from the mine sump after proper sedimentation. The total quantity of raw water required has been estimated to be approximately 477,100 gallons per day (gpd), as shown in Table 4-3-6.

The purpose of the raw water treating facilities is to produce the following water qualities:

- Demineralized water for steam boiler make-up
- Process water
- Cooling water make-up
- General service water
- Potable water
- $SO_2$ scrubber make-up water

Make-up raw water needed for processed shale moisturization will not be treated.

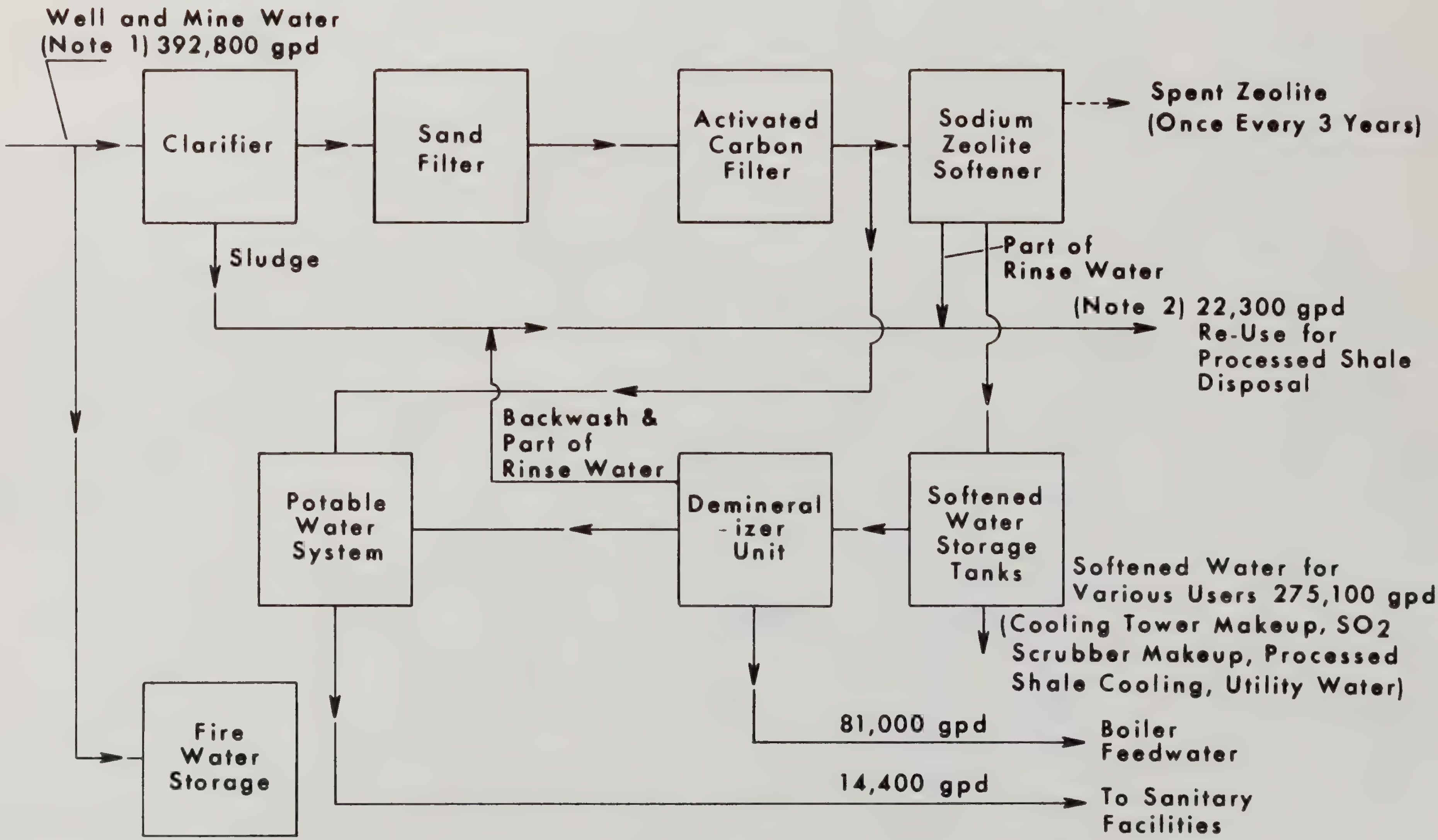
Because of the suspended solids and organic material content of the raw water, and its high alkalinity and associated hardness, the following raw water treating facilities are planned: (See Figure 4-3-3 Block Flow Diagram - Water Treatment)

1. <u>Clarification</u> - Chemicals (alum, polyelectrolytes) will be fed into the raw water to remove suspended solids in a clarifier.

2. <u>Sand Filtration</u> - The overflow from the clarifier will be sand filtered to reduce suspended solids to a concentration of 1-2 mg/1.

3. <u>Activated Carbon Filtration</u> - In order to remove organic material, the sand filtered water will be filtered through activated carbon. Since this step acts as a polisher, the carbon usage will be low. Consequently, carbon regeneration facilities are not warranted.

4. <u>Zeolite Softening</u> - In order to avoid calcium carbonate scaling in such unit operations as steam condensing, process cooling, and processed shale cooling by direct water injection (spray nozzles), the carbon filtered raw water will be softened by passing it through sodium zeolite resin beds. The regeneration of the zeolite resin will be made with sodium chloride solution.




Notes 1. Mine Water Used for Processed Shale Moisturization is Not Included Here.
2. This Represents Only a Part of Re-Used Water. Other Re-Used Water for Processed Shale Moisturization is Not Shown.

Figure 4-3-3
Block Flow Diagram—Water Treatment

The filtered and softened raw water will be sent to a storage tank for further distribution to users (process, general service, and cooling tower make-up water) and to demineralization.

5. Demineralization - In order to produce make-up water suitable for a 560 psig steam boiler operation, the softened water may undergo complete demineralization.

The demineralization plant, if used, will consist of the following treatment steps:

- Cation exchange
- Degassing ($CO_2$ - stripping)
- Anion exchange
- Cation/anion exchange (polishing)

The design capacity of the demineralization plant will be 90 gpm.

After the last treating step, the demineralized water will be sent to a two-day storage tank before being fed to the steam boilers in the plant via deaeration.

The regeneration of the ion exchange resins above will be made with aqueous solutions of acid (cation) and sodium hydroxide (anion). The regeneration water and part of the rinse water will be sent to a neutralization pit, while backwash water and last rinse will be returned to the clarifier inlet for recovery.

Potable water will be made from a mixture of demineralized and activated carbon filtered water. Ozone and separate activated carbon treating will be employed to secure potable water of acceptable quality.

B. Steam Generation - Steam will be generated from two sources:

- Lurgi waste heat steam boiler, recovering heat from the Lurgi flue gas/processed shale stream in the waste heat recovery and processed shale cooling unit. This steam is generated at 550 psig (saturated) and at a rate of about 39,200 lbs/hr.

- Two natural gas fired steam boilers, each capable of producing 73,500 lbs/hr of steam at 550 psig/600°F. Since this is a small demonstration plant, it is not economically viable to clean up product gas for use as boiler fuel.

Recovered steam condensate and demineralized make-up water are sent to a 15 psig/240°F (design) deaerator from which the boiler feed water is pumped to the boiler units described above.

Chemicals (sodium phosphate, morpholine, and sodium sulfite) are added to the boiler feed water to prevent tube scaling and corrosion.

C. Cooling Water - Zeolite softened water is used as make-up water for a closed-circuit cooling water system. A two-cell (2 x 1500 gpm circulation) cooling tower installation is contemplated to cool the 95°F return water to a temperature of 68°F (design-summer) before being pumped to the various cooling services. The cooling tower will operate at about four (4) cycles of concentration. Demisters installed in each cell will reduce the droplet carryover to about 0.01% of the circulation flow. Chemicals (biocide and acid for pH-control) will be added to the cooling water to prevent corrosion and algae buildup. No chromate will be used.

Scaling on heat exchanger tubes is basically prevented by using zeolite softened water as make-up. The cooling water pH will be kept at approximately 8 to minimize carbon steel tube corrosion.

D. Plant Air - Air compressed to 100 psig will be supplied to the plant at a total rate of approximately 4,500 lbs/hr (1,000 SCFM). After cooling and moisture removal, about half of this air quantity will be used for general services. The other half, after oil removal, will be used as instrument air.

E. Emergency Electric Power - A diesel-fueled emergency power generator will be installed to supply up to 1,000 KW of emergency power. In case of power failure, the emergency power will serve Lurgi processing and support facilities electric demands totalling about 800 KW.

F. Fire Water - Clarified raw water will be held in a storage tank (tentative volume = 400,000 gal). This tank will be furnished with steam coils to keep the fire water at about 40°F during winter. Two fire water pumps (one with diesel drive), each at a capacity of 1,000 gpm (pressure head = 150 psig) will send the water to a fire water loop in the process areas.

G. Effluent Treatment - Three categories of aqueous wastes will be generated in the Lurgi demonstration plant.

1. Wastewater Containing Suspended Solids - Raw water treatment wastes from the clarifier under flow, containing also backwash from sand filter, activated carbon filter and zeolite softener.

2. Wastewater Containing Inorganic Salts:

- Cooling tower blowdown
- Steam boiler blowdown
- Raw water treatment wastes (regeneration and rinse water from zeolite softening and demineralization)
- Blowdown from the $SO_2$ scrubber system, associated with the Lurgi product gas incineration/quench unit

3. Wastewater Containing Organic Components:

- Process condensate (gas liquor) from Lurgi condensation unit
- Oily rain water
- Process area wash down water (by way of oily sewer)
- Sanitary waste water

The wastes from category (1) are not treated, but are returned to the raw water clarifier inlet for recovery.

The regeneration wastes from the demineralization process are neutralized before being combined with the blowdowns from the boilers, cooling tower and $SO_2$ scrubber. These streams are individually collected aboveground and piped to collection storage tanks. None of these streams will be organically contaminated. The wastewater from category (2) will be reused as processed shale moisturization water. The high TDS holding pond will be provided as a back-up for storing this water, should it exceed the need of processed shale moisturization at times. The high TDS water holding pond is discussed in more detail in Part 3.3H of this chapter together with the surge pond, bio-treated effluent holding pond and the facultative lagoon.

Waste water streams of category (3) above will undergo treatment as described below (see Figure 4-3-4).

The process condensate, containing ammonia and minor amounts of hydrogen sulfide and carbon dioxide, will be sent to an oil separator and an ammonia stripper. The bottoms stream from this stripper will be sent to an evaporator, producing a distillate and a concentrate. The distillate (about 90% of evaporator feed) will undergo further treatment. The stripper overhead vent stream (containing gaseous ammonia) will be incinerated in the product gas incinerator. The evaporator concentrate (approximately 10% of evaporator feed) will be recycled to the Lurgi process.

The oily rain water and wash down water from the processing area will be collected by the oily sewer and delivered to the surge pond. It will be treated in the following sequence:

- Corrugated Plate Interceptor (CPI) for free oil separation (the cooled and neutralized evaporator distillate will be added to the CPI separator effluent and sent to the Dissolved Air Flotation (DAF) unit for removal of emulsified oils).
- DAF unit for emulsified oil removal
- Biological oxidation by means of an aerated facultative lagoon
- Effluent from the facultative lagoon will be filtered through a sand filter and treated further by an activated carbon adsorption system
- The final treated effluent will be used for processed shale cooling or other acceptable uses such as processed shale moisturization, dust control, discharge, etc.
- A holding pond will be provided as an emergency back-up.

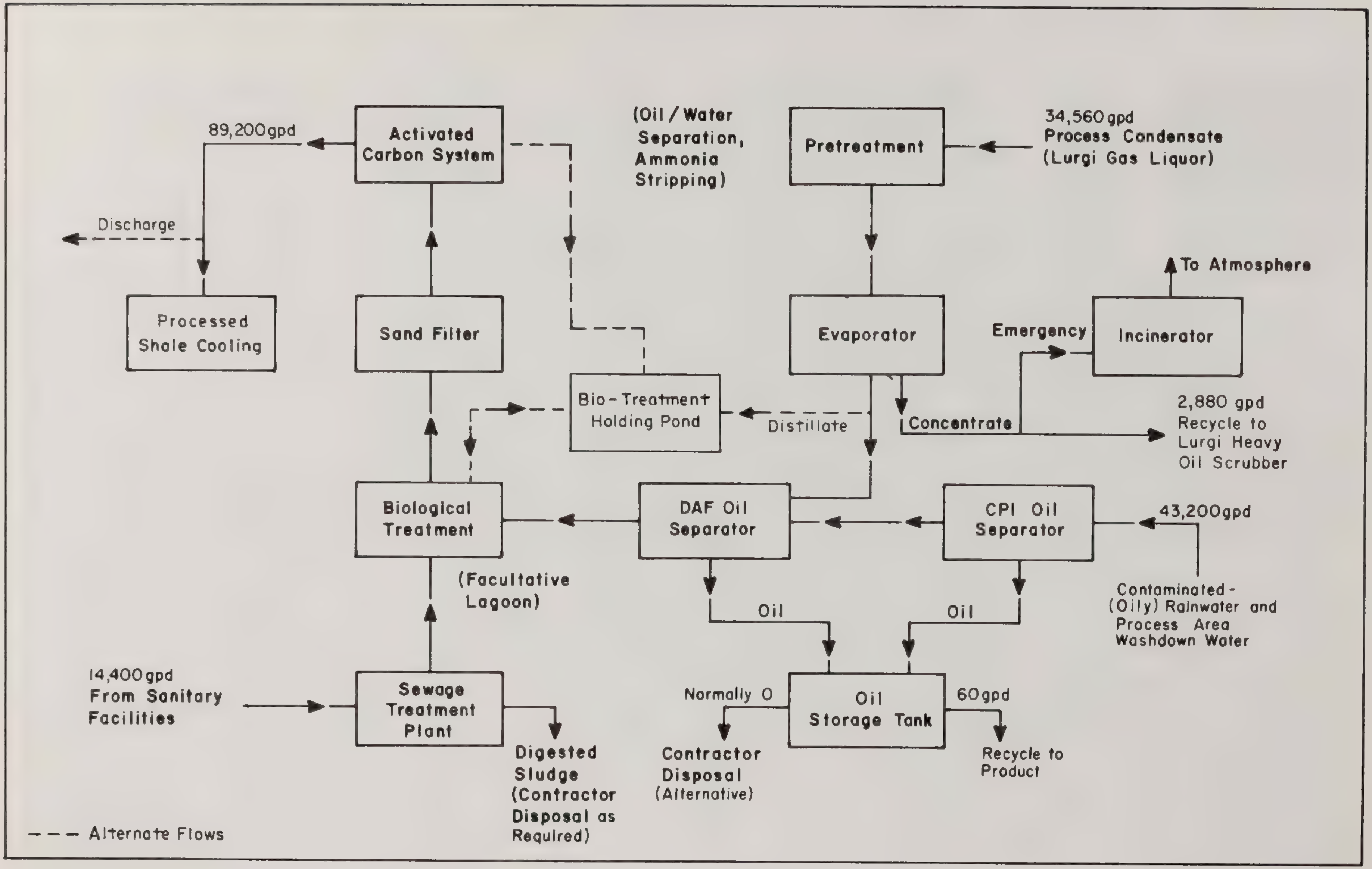



Figure 4-3-4
Block Flow Diagram-Effluent Treatment

Minor quantities of waste oil from the CPI and DAF units above will be recycled into process, or hauled away by a contractor.

The sanitary wastewater will be sent to a packaged treatement unit which includes equalization and surge, biological oxidation, clarification, and disinfection by ozonation. The treated sanitary waste stream is then sent to the facultative lagoon, and treated with the oily waters.

H. Ponds and Facultative Lagoon - Below is a general description of the design and operation of the ponds and lagoon provided for the Lurgi processing and support systems. Additional discussion of these and other ponds is given in Section 7, Chapter 6.

The following are discussed herein:

- Surge pond
- Biological facultative lagoon
- High TDS water holding pond
- Bio-treated effluent holding pond

1. Surge Pond - This pond is provided to accommodate flow fluctuations (surges) in the washdown and oily rain water runoff from the processing areas. Wastewater collected in the surge pond will be delived to the CPI oil separator for treatment at a steady flow rate.

The pond will have a design surge capacity of 75,000 gallons. It will be an earthen pond and be provided with a plastic liner and an under-liner leakage detection system. The water level in the surge pond will vary with operation. It is expected to be normally dry or at a low level, since no minimum detention time of wastewater is required.

2. Biological Faculative Lagoon - The facultative lagoon will provide the necessary biological treatment of the process wastewater as well as the treated sanitary effluent. Aeration equipment will be provided in the lagoon.

The lagoon will be an earthen structure with a design capacity of approximately five acre-feet. It will be provided with a plastic liner and an under-liner leakage detection system. It will be operated near the design water level; however, adjustment in operating level may be necessary to optimize the operation.

3. High TDS Wastewater Holding Pond - This pond is provided for the retention of the category 2, high TDS water, when it exceeds the need for processed shale moisturization. It has a design capacity of approximately 35 acre-feet. It will be provided with a clay liner or equivalent seepage control such as sodium bentonite sealing of the pond bottom. A leakage monitoring system will also be provided for this pond.

4. Bio-treated Effluent Holding Pond - This pond serves as emergency retention for bio-treated effluent when it is not used for processed shale cooling or not discharged to Corral Gulch. Since the bio-treated effluent normally is associated with the operation of the Lurgi processing unit as well as the processed shale cooling requirement, it is expected to be totally consumed for processed shale cooling. Consequently, the bio-treated effluent holding pond will normally be empty.

This pond has a design capacity of approximately 12 acre-feet. It will be an earthen pond completed with a plastic liner and under-liner leakage detection system.

I. Product Gas Disposal - (see Figure 4-3-5)

The product gas from Lurgi condensation unit is a 980 Btu/SCF gas. A portion is reused in the Lurgi retort unit as auxiliary fuel for the recycle shale lift pipe. The excess, approximately 70 x $10^6$ Btu/hr, will be sent to an incinerator. In case of an emergency (incinerator shutdown), the excess product gas will be flared.

This product gas will be combusted in a refractory lined, horizontal cylindrical incinerator, designed for the totality of the product gas plus minor hydrocarbon vents from heavy oil dedusting unit. In addition, the gaseous

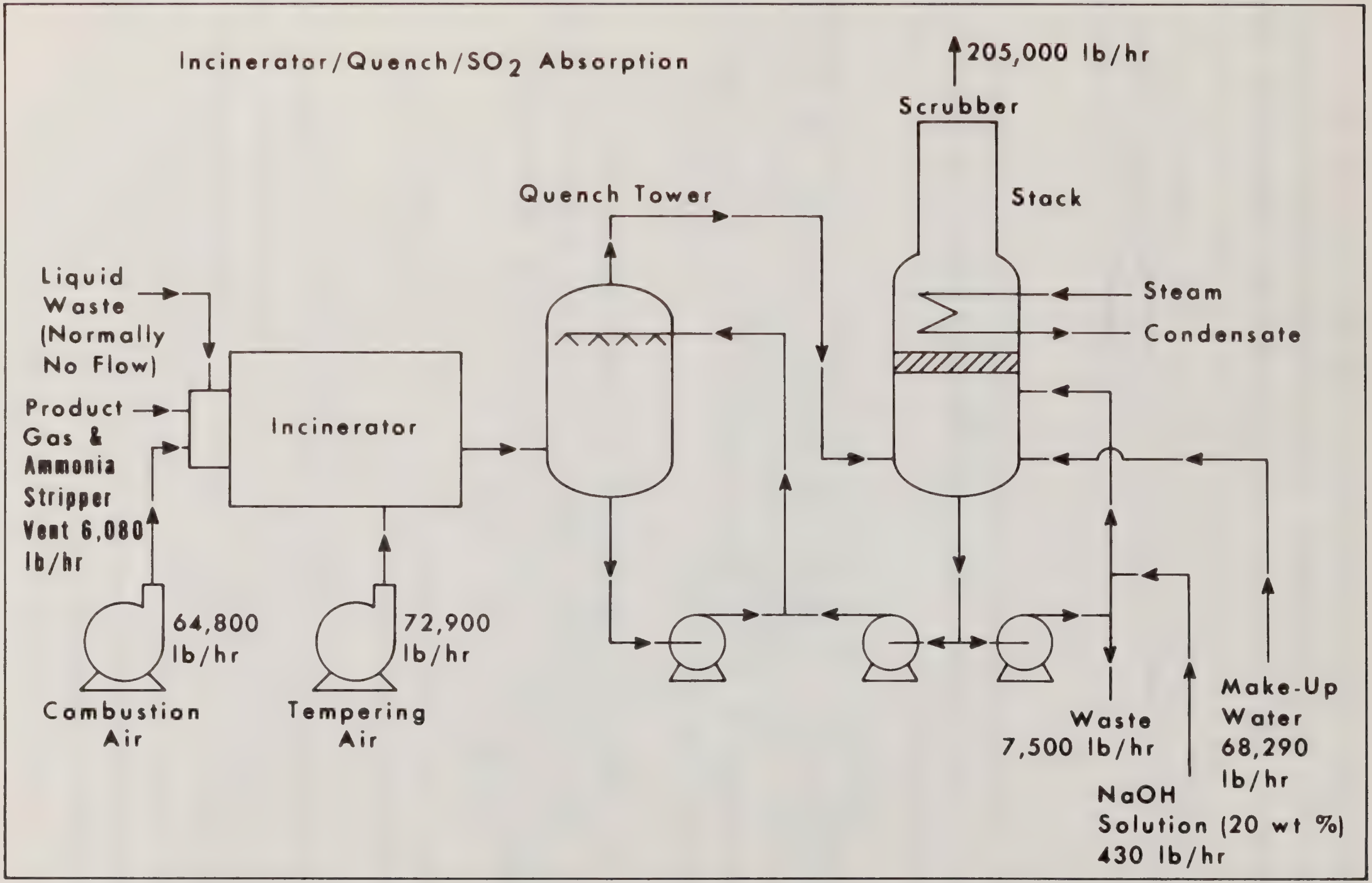



Figure 4-3-5
Schematic Flow Diagram - Incineration & Cleaning of Product Gas

ammonia vent stream from the process waste water stripper (see Part 4.3.G above) will be co-incinerated. The approximately 1,700 lbs/day of ammonia produced in this demonstration unit is insufficient for economical recovery.

The combustion temperature in the refractory lined incinerator will be kept at a minimum temperature consistent with a high destruction efficiency (with excess air) at which conditions all sulfur compounds should be converted to $SO_2$.

After completed combustion, the flue gases will enter an evaporative quench vessel, where injected water will evaporate and cool the flue gases to approximately 500°F.

Subsequently, the flue gases enter an $SO_2$ scrubber with a drop separator, a mist eliminator, and a steam coil reheater. The latter will increase the temperature of the near saturated flue gases to about 220°F to avoid stack condensation. If the MIS schedule permits, the existing MIS scrubber may be relocated to the Lurgi site.

The $SO_2$ removal in the scrubber is accomplished by addition of sodium hydroxide to the scrubber solution. The absorbed $SO_2$ will be disposed as sodium sulfite in the scrubber blowdown to the high TDS water system, which oxidizes to the sulfate when exposed to air.

The flue gases will ultimately be discharged to the atmosphere by a stack, 310 feet above ground level.

J. Processed Shale Moisturizing - Processed shale, at approximately 200°F, discharges from the processed shale cooler into the processed shale moisturizer. In the moisturizer, (a screw mixer or rotating drum similar to a rotary kiln) water is sprayed on the turbulent solids bed to achieve a uniform moisture content. The conditioned, processed shale is discharged to the processed shale disposal conveyor system. Figure 4-3-6 is a schematic drawing of this operation.

Moisture input will be in the range of 15 to 20% by weight. At full production capacity and at the normally expected 17.5% moisturizing, water demand will be 147,600 gpd. This water will be supplied from high TDS water and from the water well supply system or the mine system holding pond.

The overall water management plan for the processed shale disposal system is discussed in Section 7, Chapter 6.

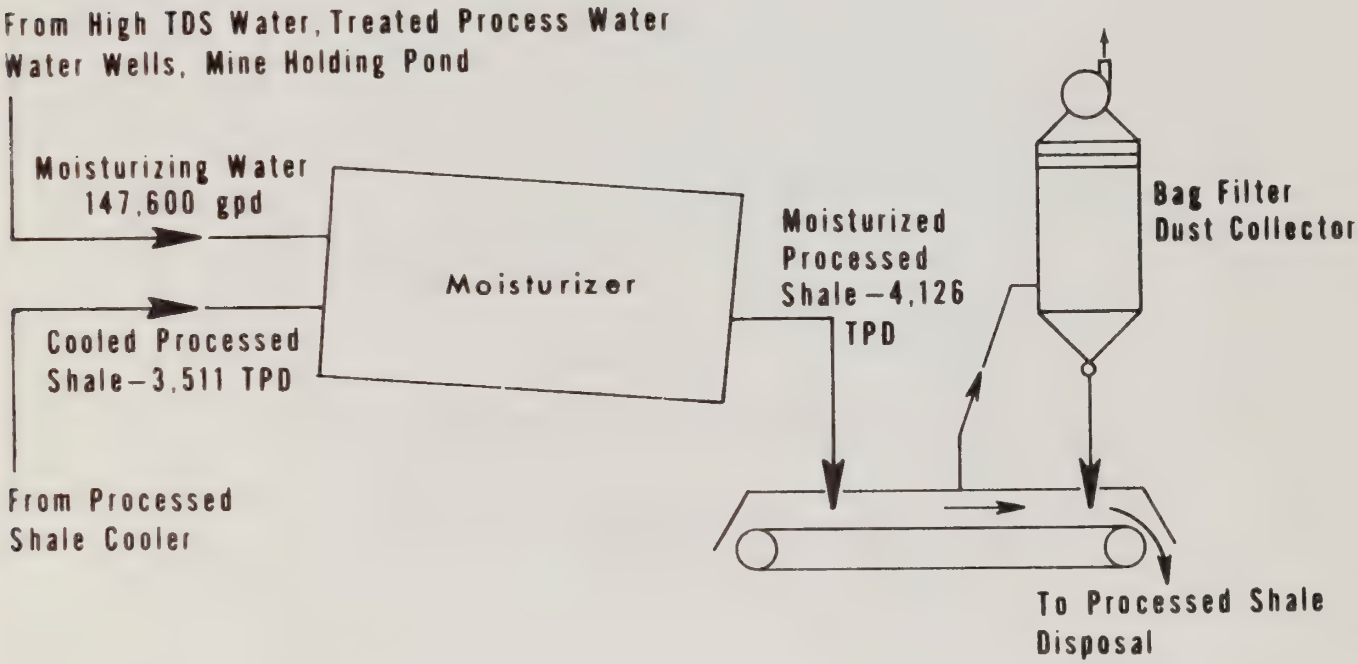



Figure 4-3-6
Schematic—Processed Shale Moisturizing

K. Consumptive Use of Water - Consumptive use of water for the demonstration plant as designed is about 5.1 barrels of water per barrel of oil produced based on 2,230 bpd of oil produced and 477,100 gpd water consumed. This water consumption is not applicable to a commercial plant because many design criteria will be changed. Based on very preliminary estimates, water consumption is expected to be significantly less for a commercial plant.

# Section 5

# PROCESSED SHALE and OVERBURDEN DISPOSAL

CHAPTER 1

INTRODUCTION

## 1.1 SCOPE

This Section presents the concepts and design of a processed shale storage facility for the Lurgi demonstration plant to be constructed and operated on the RBOSC off-tract property adjacent to Tract C-a. The location of project site is shown on Figure 1-1-4. The principal purpose of the design is to provide a processed shale disposal system which will minimize impacts to the environment. The disposal system is designed to demonstrate proposed technology and to collect pertinent data which will be helpful in optimizing the operation for the processed shale disposal system for the commercial operation. The selected design is considered to be the most cost effective means of accomplishing these objectives.

## 1.2 PROJECT BACKGROUND

The requirements for the Lurgi Demonstration Project include the disposal of overburden from an open pit and of processed oil shale from the Lurgi demonstration plant. The Lurgi Demonstration Project will be carried out in two phases at a production rate of 4,400 tons of raw ore per day. A disposal facility is required for a total of three million tons of processed shale for the two phase operation. Associated with the two phases will be the excavation of an estimated total of 9.4 million bcy of overburden material from the open pit and 0.5 million bcy from a cut made during the haul road construction. This material is available for use as a construction material for haul roads, for processed shale disposal facilities and for open pit backfilling. A portion of the overburden will be low-grade ore and will be utilized in such a way that it can be recovered in the future.

This discussion sets out the concepts and design of the overburden/low-grade ore/processed shale disposal facility for the Lurgi Demonstration Project. Disposal planning and design for processed shale are presented in Chapter 2. Topics addressed include:

- Characteristics of processed shale
- Design criteria
- Site selection and preparation
- Disposal material conditioning and transport
- Major structures and civil works
- Reclamation
- Water management
- Dust control

Chapter 3 is a description of the overburden waste disposal operation including the estimated quantity of overburden generated by each phase of mining development.

Chapter 4 presents proposed demonstration and data collection programs related to processed shale disposal. The objectives of these programs are to demonstrate proposed technology and to acquire sufficient data for optimizing the design and operation of a commercial system. The arrangement of programs is designed to coordinate with the proposed mining and retorting production schedules, beginning with Phase I mine development and extending through Phase II operations. The scope of the programs covers the various environmental and mining operational aspects such as:

- Materials handling
- Stability of waste
- Leachate quality and quantity
- Reclamation
- Erosion
- Dust Control

## 2.1 DESIGN CRITERIA

The disposal plan for the processed shale was designed to comply with the following regulations:

- Colorado Mined Land Reclamation Rules and Regulations, amended June 1978 (as per Colorado Mined Land Reclamation Act, 1976)
- Regulations for Solid Waste Disposal Sites and Facilities (as per Subtitle D-RCRA), Colorado Department of Health
- Tract C-a Oil Shale Lease
- NPDES (National Pollution Discharge Elimination System), Colorado Department of Health and U.S. Environmental Protection Agency
- Rules and Regulations for Plans and Specifications for the Construction of Reservoir Dams, Division of Water Resources, Office of the State Engineer of Colorado
- Prevention of Significant Deterioration (PSD), Total Suspended Particulate (TSP), limitations (as per 1977 Clean Air Act Amendments), U.S. Environmental Protection Agency

At the proposed production rate of 4,400 tons per day of raw shale the estimated processed shale quantity for disposal is 1.2 million tons for Phase I operation and 1.8 million tons for Phase II operation. The required disposal volume was determined using an estimated density of 65 pounds per cubic foot uncompacted and a moisture content of 15% to 20% by weight. Therefore, the total processed shale volume would be 1.37 million cubic yards for Phase I and 2.05 million cubic yards for Phase II operation.

Processed shale disposal operations for Phase I have been planned to meet initial disposal requirements and to accommodate Phase II requirements. Phase II processed shale disposal operations are presented in more general terms outlining design concepts and will be capable of modification to take advantage of the experience obtained in Phase I. As demonstration and testing programs are completed on the disposal facility in both Phase I and Phase II, it will be progressively reclaimed and revegetated. See Section 7, Chapter 8 for reclamation procedures.

## 2.2 CHARACTERISTICS OF LURGI PROCESSED SHALE

A. General - Until the Lurgi demonstration plant is constructed and operating, the characteristics of the processed shale will not be completely known. However, its characteristics have been anticipated from laboratory studies on material obtained from Lurgi test runs made in 1976. This material was composed of an approximately 50:50 mixture of materials collected from a cyclone and an electrostatic precipitator and was from a run which had a burn temperature and duration comparable to those anticipated in the demonstration plant. Prior to the addition of moisture the material is in the form of a dark grey, fine powder. With the addition of water the processed shale becomes quasi-plastic and with time develops into a relatively strong and impervious material. Results of laboratory tests carried out to date are summarized below.

B. Index Properties - The processed shale is made up of irregular grains and has a specific gravity ranging from 2.61 to 2.68. Mineralogical analyses by Colorado School of Mine Research Institute (CSMRI) using x-ray diffraction indicate that the material is composed of approximately 36% $CaCO_3$ and 33% $SiO_2$ with the balance split more or less equally between ($CaCO_3$ $MgCO_3$) and (Na, Ca) Al (Si, Al) $Si_2O_8$. Additional analysis conducted by Hazen Research, Inc. indicated Lurgi processed shale contains 1.2% $SO_4$. The Hazen analysis was performed according to ASTM D2492-79 procedures. The size gradation of the material is mainly in the silt range and Atterberg limit determinations indicate the material to be nonplastic (Figure 5-2-1). Also shown on Figure 5-2-1 are the compaction characteristics of the processed shale. These show the effects which moisture content and compactive effort have on the densities which can be achieved with this material. The achieved densities are relatively insensitive to the amount of water, particularly in the lower ranges of moisture content.

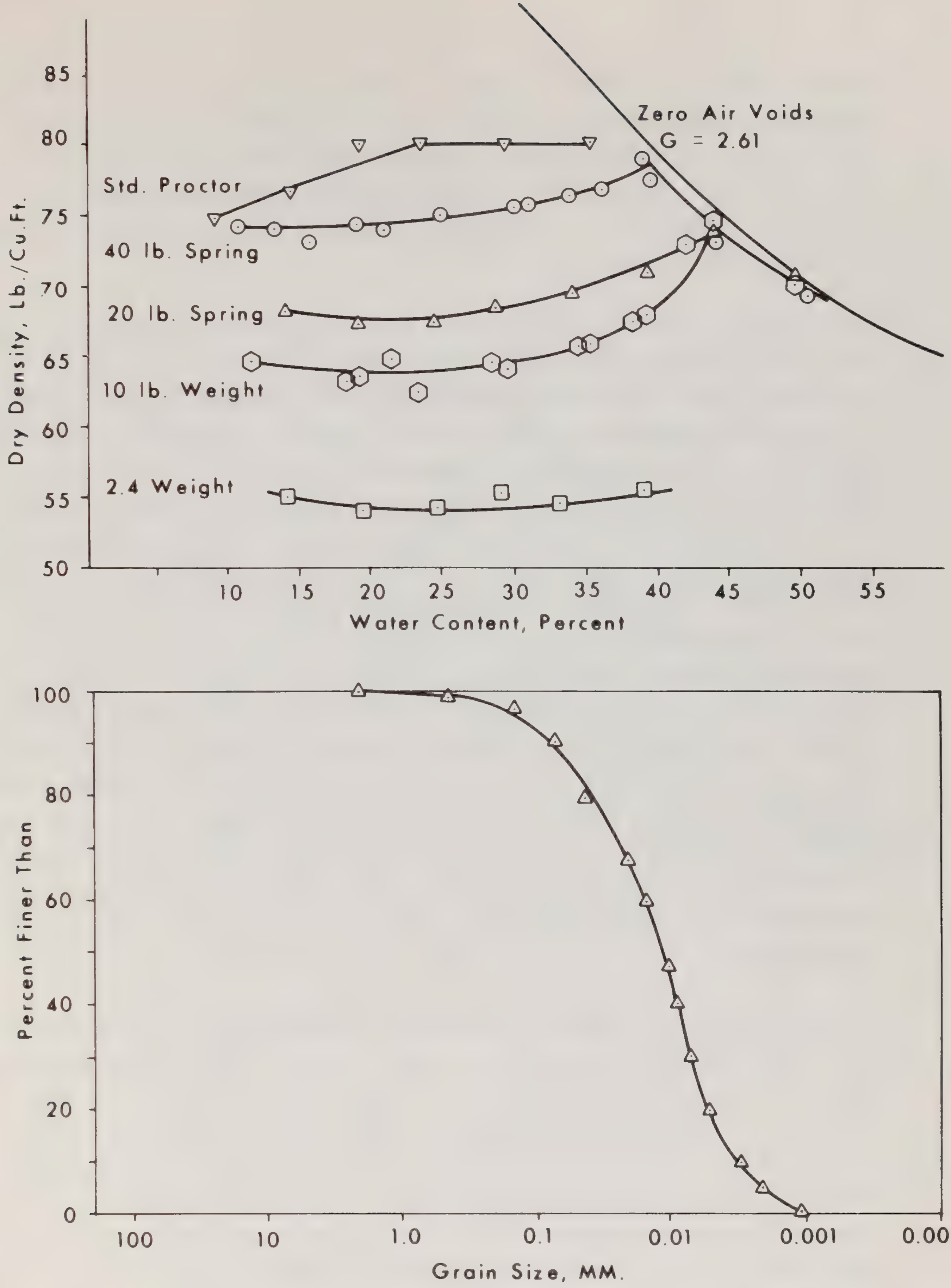



Figure 5-2-1

Laboratory Compaction Test Results RBOSC Processed Oil Shale - Harvard Miniature

Standard Proctor dry density, which is comparable to the low range of what might be expected using conventional construction compaction equipment in the field, is of the order of 80 pcf. Achieved densities drop off substantially with lower compactive efforts. By contrast, the maximum density which can be achieved by vibration of dry material averaged 69 pcf; corresponding minimum density for dry material was 42 pcf.

C. Strength - Preliminary testing of the strength characteristics of the Lurgi processed shale has been carried out. From previous work, it was anticipated that in addition to moisture content and density, the variables of time and temperature might have an important influence on strength development. Choosing unconfined compressive strength as an indicator of strength, cylindrical samples for testing were formed at moisture contents of 15%, 20% and 67%, the latter being a 60-40 slurry. These were cured under humid conditions at temperatures of 35°F, 70°F and 150°F and tested at various times. The results of the tests are shown on Figures 5-2-2, 5-2-3 and 5-2-4 and indicate clearly that both time and temperature have important effects on strength development for the material tested. The data also indicates that the processed shale is capable of developing significant strength under the right conditions, probably by some sort of chemical cementing action, but further work will be required to determine the practical implications of the data. As a further indication of the long term strength of the material, a series of drained triaxial tests were carried out at 20% moisture and in a 60:40 slurry. The results of these suggest that conditions are favorable for the long term stability of the material (Figure 5-2-5).

D. Consolidation - Preliminary laboratory study of the consolidation properties of the processed shale has also been carried out and the results are shown on Figure 5-2-6. As in the case of the strength, the effect of time is significant in determining consolidation characteristics. For curing times of 14 and 29 days, the compressibility of the material is substantially reduced up to an applied pressure of 3 to 4 tons per square foot (tsf). Above this pressure compressibility is essentially similar to a freshly placed sample. This apparent preconsolidation effect, as in the case of the strength, is probably due to a cementing action.

Samples Compacted With Harvard Miniature, 40 lb. Spring, 15% Water Content.

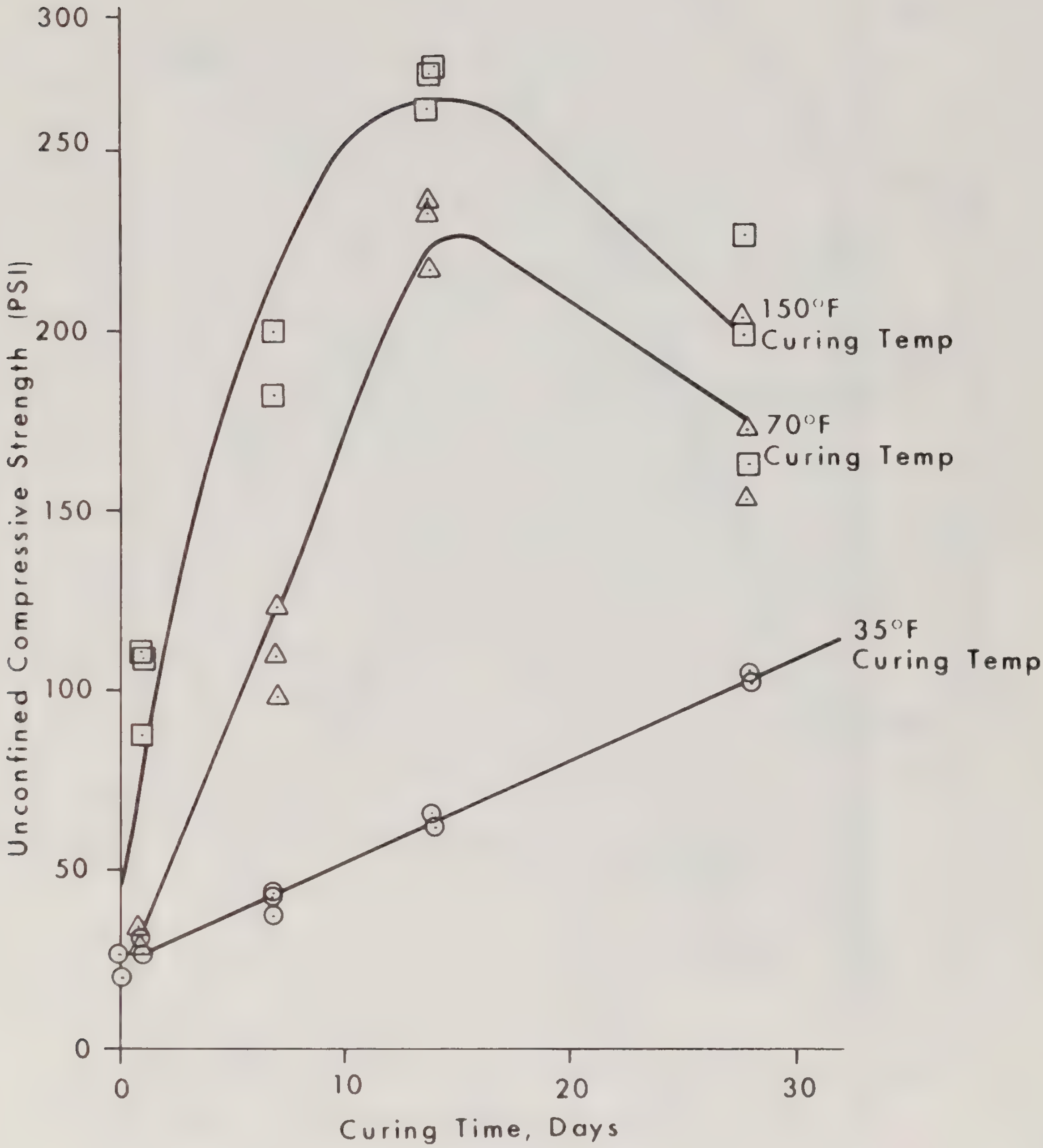



Figure 5-2-2
Unconfined Compressive Strength vs. Curing Time
RBOSC Processed Oil Shale

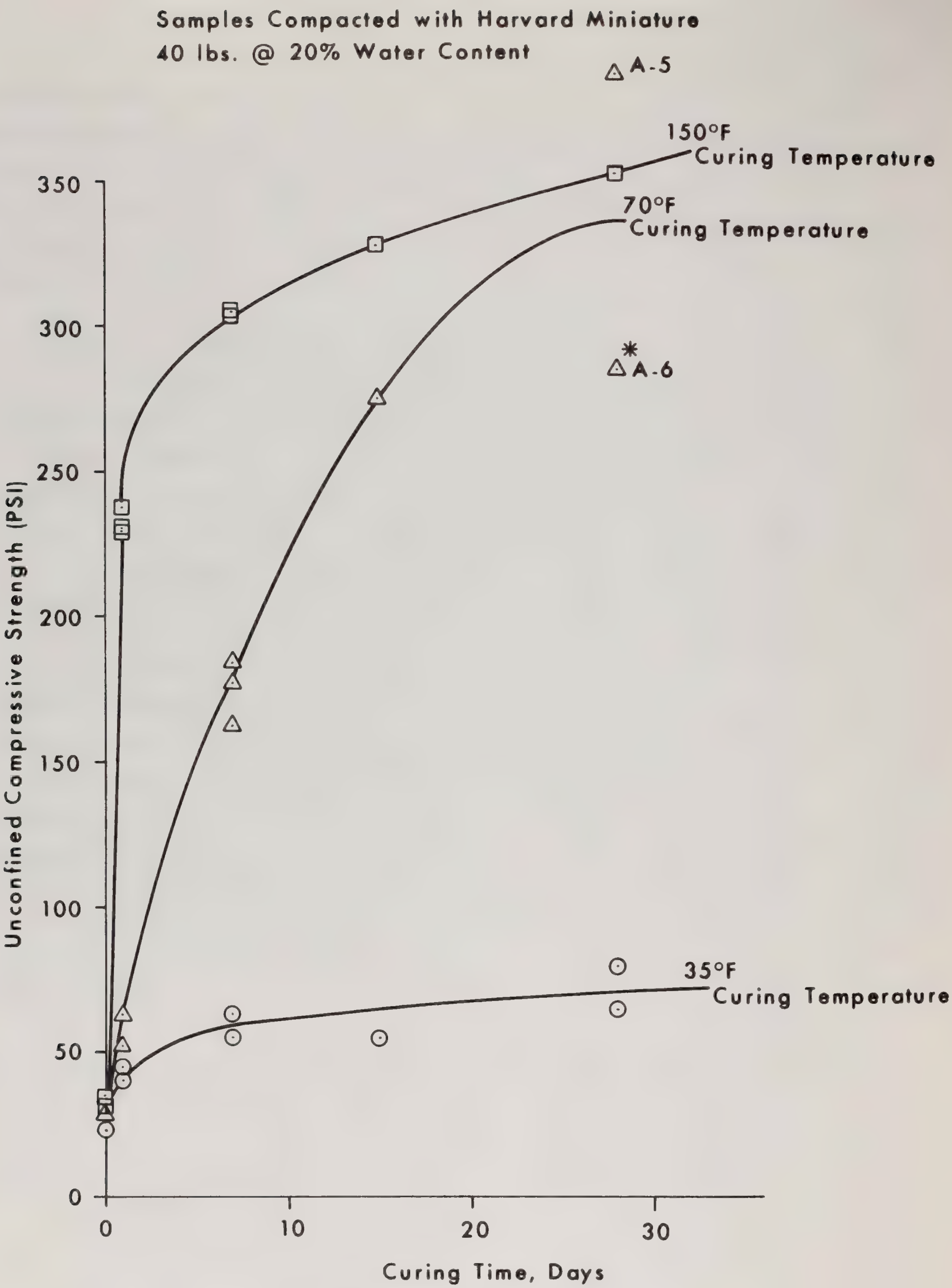



Figure 5-2-3

Unconfined Compressive Stength vs. Curing Time - RBOSC Processed Oil Shale

Slurry Mixture

60% Solids

40% Water

Samples Formed in Molds and Removed as Soon as Adequate Strength Had Been Achieved

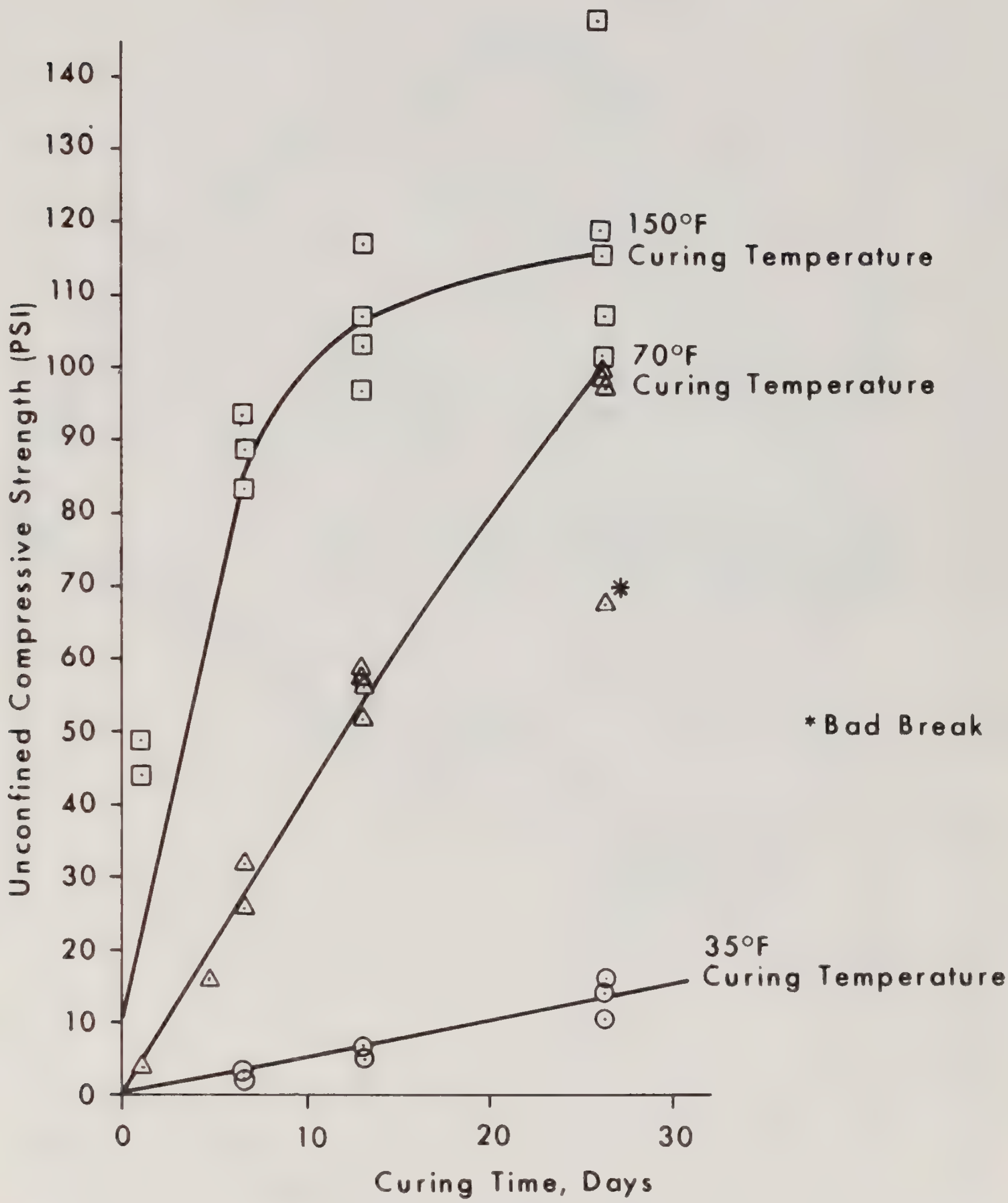



Figure 5-2-4
Unconfined Compressive Strength vs. Curing Time
RBOSC Processed Oil Shale

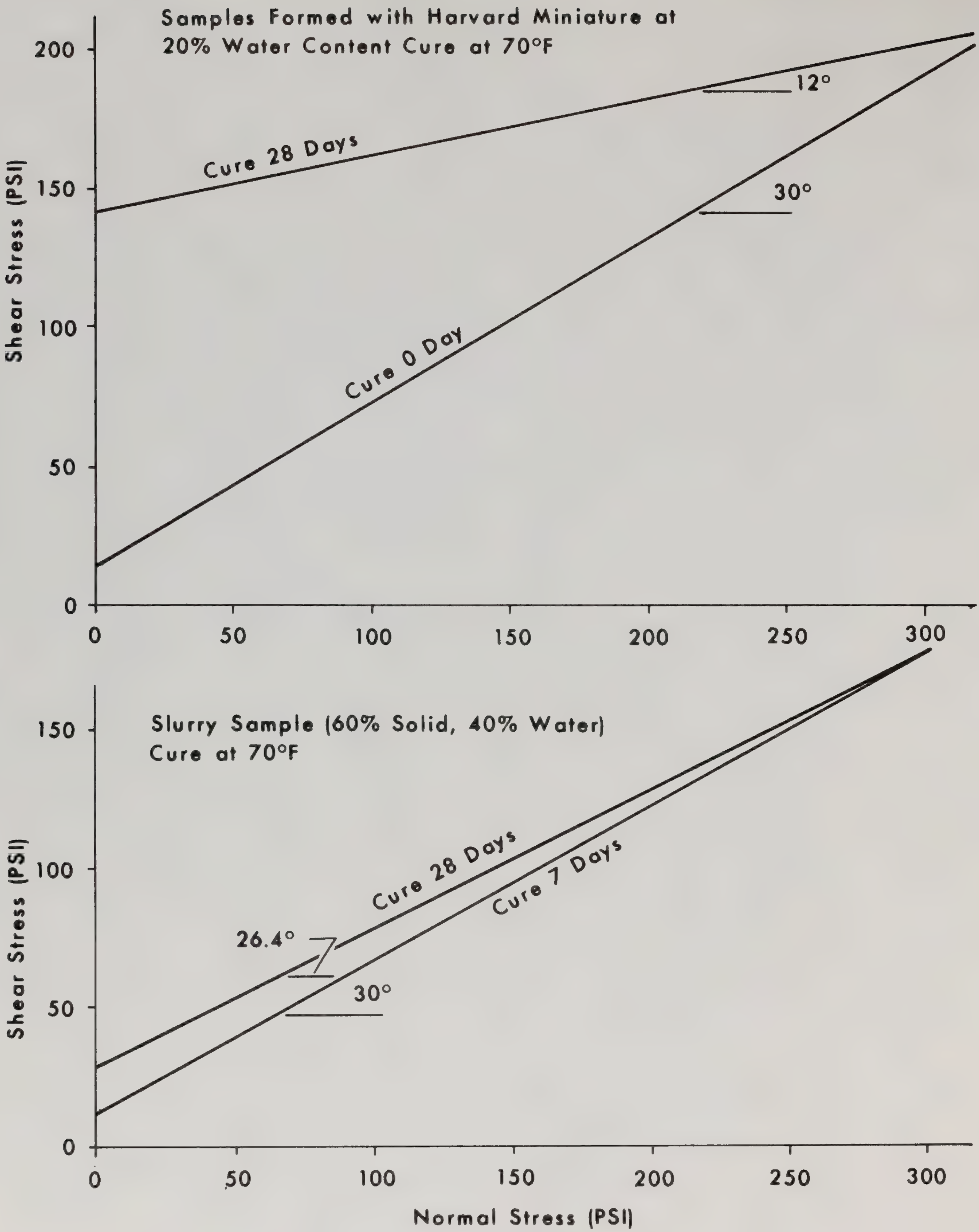



Figure 5-2-5
Triaxial Test Consolidated Drained Unsaturated

Slurry 0, 14, and 28 Day Curing at 70°F 16 Minute Load Intervals

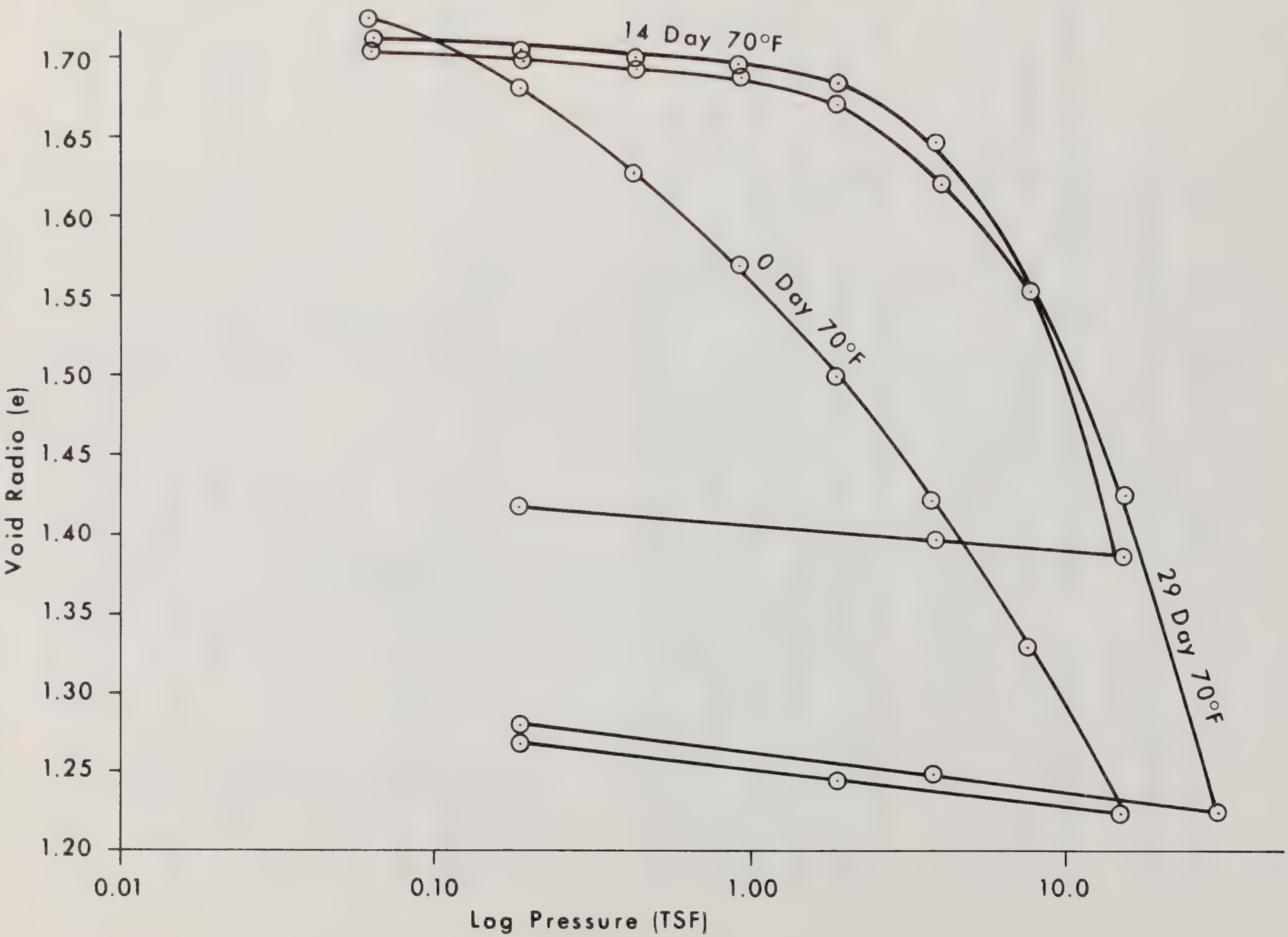



Figure 5-2-6
Consolidation Tests Void Ratio vs. Log Pressure

E. Permeability - Laboratory tests have been carried out to determine the permeability (hydraulic conductivity) of the material. Again, a time effect has been noted as shown in Figure 5-2-7, which gives the results of permeability determinations made over a period of time in a single sample. A drop in permeability of an order of magnitude from $k = 4 \times 10^{-5}$ to $k = 3 \times 10^{-6}$ cm/sec was observed, confirming similar results obtained by AMOCO Laboratories. Work by CSMRI has suggested that this measured decrease in permeability may be due to crystal growth in the pores.

F. Angle of Repose - Angle of repose is not a fundamental engineering property, but it is a parameter frequently used in the design of disposal systems. Laboratory tests indicate that for dry material, the average angle of repose will vary between 38° and 41°.

G. Slurry Characteristics - Preliminary rheology studies have been carried out by CSMRI to determine the characteristics of the processed shale in slurry form, because this is a potential means of transporting this waste from the retort to the disposal facility. These studies indicated that the slurried processed shale behaves as a non-Newtonian fluid and that the Bingham plastic model provided a good fit to the experimental flow behavior. Flow constants derived from this model were as follows:

| Slurry Concentrate (Wt % Solids) | Slurry Sp. Gr. | Yield Stress (dyne/cm$^2$) | Plastic Viscosity (dyne sec/cm$^2$) |
|---|---|---|---|
| Temp. 80°F; 0.425 inch diam. tube | | | |
| 57.9 | 1.570 | 277.03 | 1.196 |
| 52.2 | 1.486 | 38.36 | 0.297 |
| 43.1 | 1.370 | 3.28 | 0.105 |
| Temp. 80°F; 0.815 inch diam. tube | | | |
| 57.9 | -- | 355.46 | 0.928 |
| 52.2 | -- | 39.00 | 0.297 |
| 43.1 | -- | 4.81 | 0.159 |
| Temp. 180°F; 0.425 inch diam. tube | | | |
| 52.5 | 1.490 | 55.64 | 0.165 |

It was concluded that the optimum slurry for minimal viscosity and yield stress would contain about 40% solids.

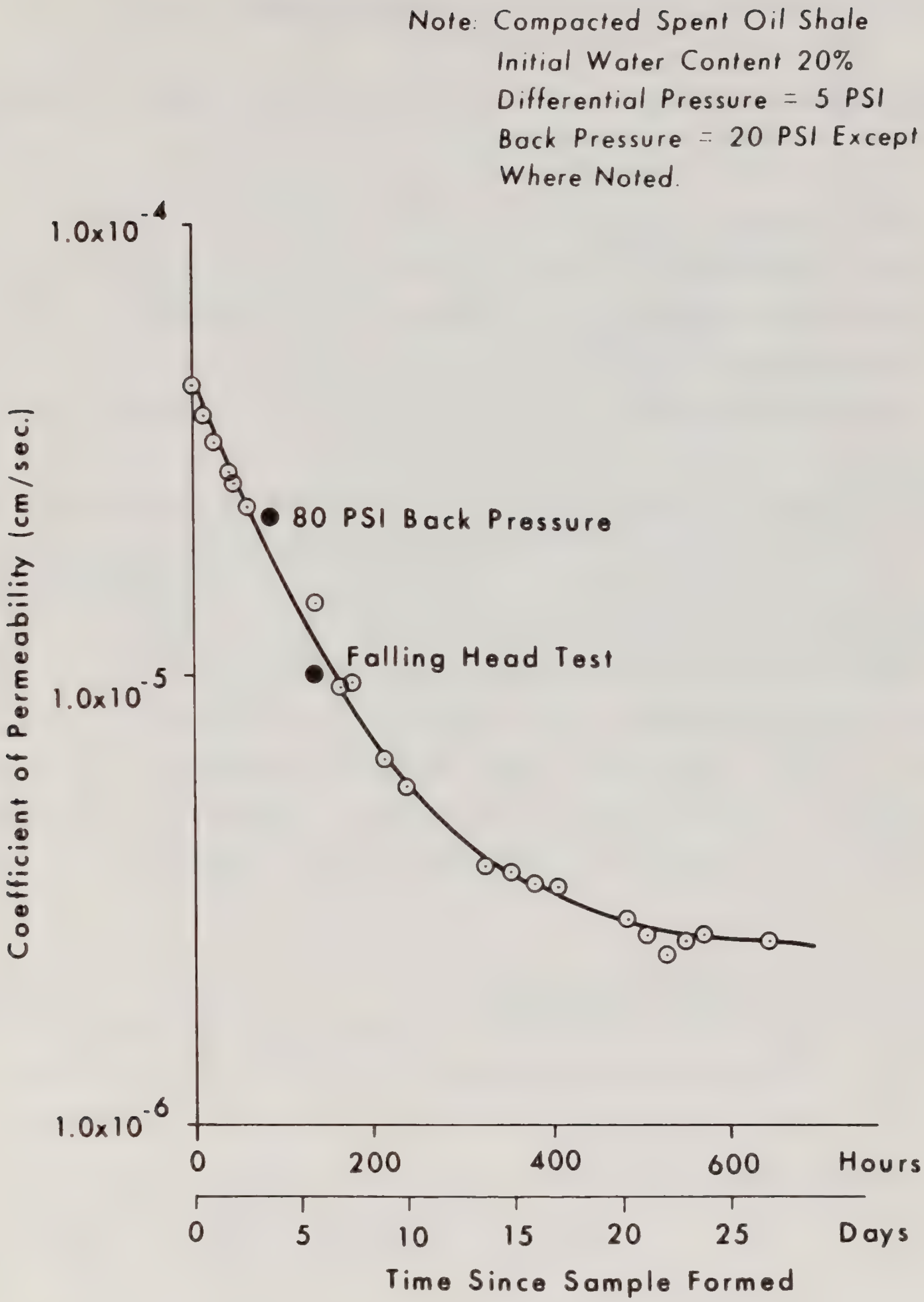



Figure 5-2-7
Coefficient of Permeability vs. Sample Curing Time

## 2.3 SITE SELECTION

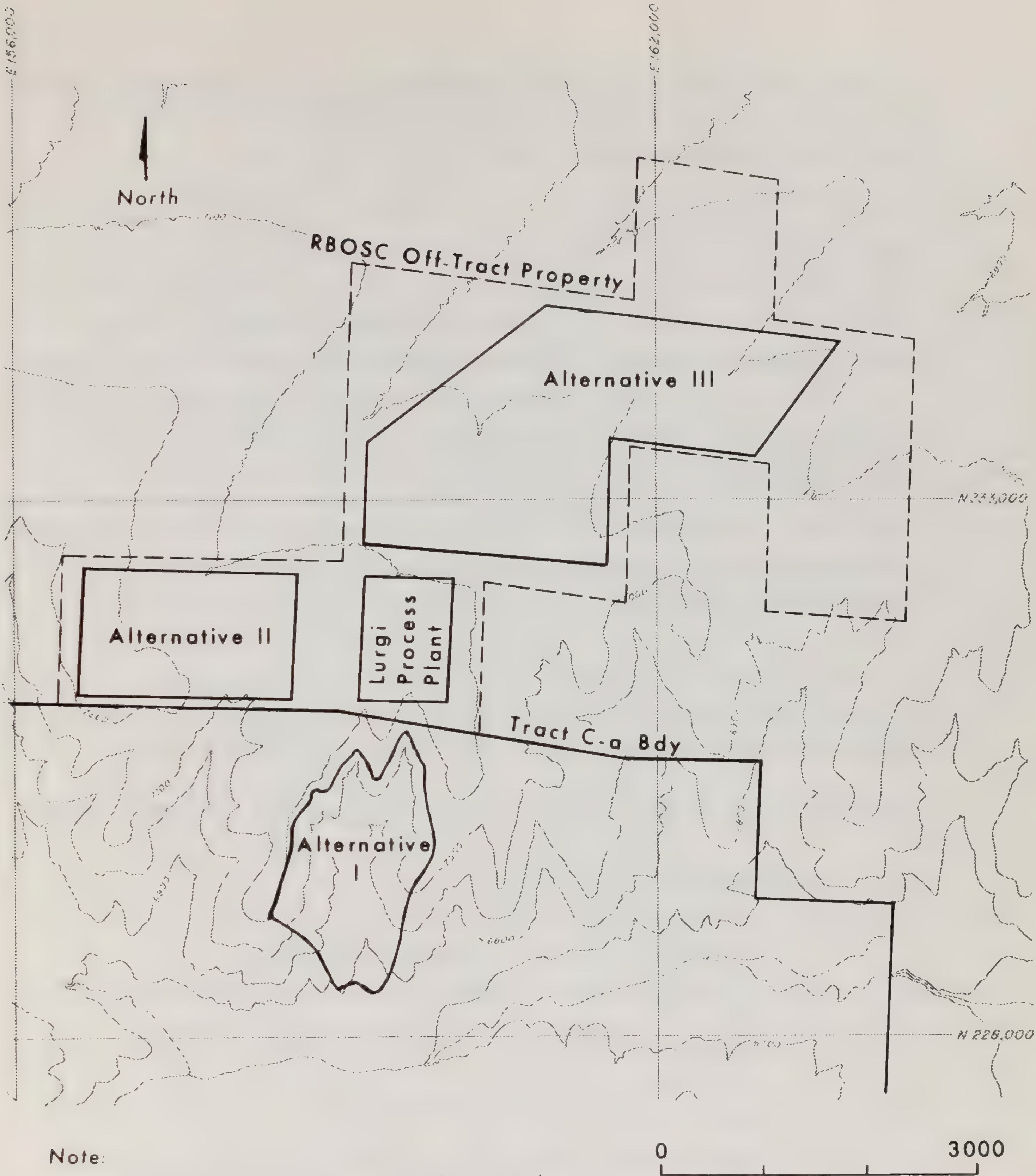
The selection of the site for the test processed shale facility involved a number of steps from original concept to final choice. This section sets out the main criteria of choice and the evolution of the site concept. The site alternative areas and site contours are shown in Figure 5-2-8.

A. Site Selection Criteria - The criteria for site selection and facility design were, in order of importance:

- Environmental acceptability
- Ability to perform experiments and collect data which would aid in optimizing the design and operation of a commercial scale processed shale disposal facility
- Cost effectiveness

B. Valley Disposal (Alternative I) - The first system of disposal considered was a head of valley fill in the draw to the south of the Lurgi process area. This is a conventional solution to disposal, and has a number of permitting, experimentation, and cost advantages. After consideration, it was decided that although this might be the least expensive disposal option, it would not allow much of the important experimentation to be performed. The irregular thickness of the pile would make leachate, compaction, and revegetation demonstrations difficult, and the collection of leachate at the base of the pile, which is an important experimental design goal, would be almost impossible.

C. Dual Disposal System (Alternative II) - In order to overcome these problems, a dual disposal option was evaluated, with a temporary test dump being set up in the westernmost section of the RBOSC off-tract property. The valley fill would then be the final disposal site for all processed shale, but the important test work would be done on a separate 20 acre plot. This solution has some attraction from a demonstration point of view, but is less attractive because of the increase in disturbed land area, and because of previous plans for use of the test area for raw shale stockpile. Also, the surface area available for experimentation was somewhat small for the number




Note:
Scheme II Disposal System is a Dual Disposal System Including Sites of Alternatives I & II North

Figure 5-2-8
Locations of Alternative Spent Shale Sites

of experiments and demonstrations contemplated. Finally, the double handling of the shale incurs considerable expense, and would delay revegetation of the final processed shale disposal area.

D. Mesa Disposal (Alternative III) - Based on the above, it became clear that an ideal site from the point of view of experimentation would be a site on a large relatively flat piece of land. The most attractive nearby location is a broad ridge or mesa running through the central portion of the RBOSC off-tract property. However, this processed shale disposal concept posed some potential permitting problems, because of the likely increased erosion potential, exposure to wind, and possible stability problems. To overcome these problems it was decided to incorporate the processed shale disposal system into the overburden stockpile in such a way as to completely enclose the processed shale with placed rock enbankments. A balance of the processed shale and overburden suggested that this would provide an excellent final disposal facility.

A further permitting problem is the interruption of watercourses. This can be overcome on this site by some minor diversion and collection of all runoff from the facility in channels which discharge to a settlement pond.

The attractions of final disposal on the mesa in this way are as follows:

1. Permitting

- Erosion of processed shale can be eliminated
- Overall stability is independent of the processed shale properties
- Revegetation demonstrations and experiments can start early in the project
- Runoff can be collected and controlled
- Stripping and stockpiling of topsoil is easy and topsoil is easily available for revegetation
- There is limited interruption to topography and drainages
- Depth to ground water is substantial (450-500 feet)

2. Experimentation and Demonstration Program

- The area lends itself to a relatively constant thickness of processed shale which aids collection and interpretation of leachate data
- Leachate can be collected and analyzed in separate compartments
- Parts of the surface of the disposal area become available for experimentation early in the project
- The experimental revegetation of the pile can become the final revegetation depending on results
- Different research efforts can take place in different areas at the same time (e.g., leachate, vegetation, compaction, slurry disposal, erosion, and slope stability)

E. Design - Based on the above discussions, a mesa disposal system for the processed shale containment facility was selected. The fundamental design concepts used are as follows:

- The processed shale will be entirely contained by wide stable rock berms constructed of overburden from the mine to eliminate potential stability and erosion problems
- During construction and operation, the rock berm areas will drain to a single sedimentation pond to control turbidity
- During construction and operation, the processed shale surface runoff will be contained within the water management system (a zero discharge of contaminants concept)
- Leachate from the Phase I processed shale facility will be collected and representative samples will be analyzed

The layout of the facility is shown on Figure 5-2-9.

The processed shale containment facility will not be activated until the first quarter of 1983. Presently, the detailed engineering of the facility, which includes the timing of the various test areas, is not complete. As the details are developed, they will be submitted to the OSO for review and approval. The sequence of activities which will be used to develop the processed shale containment facility is as follows:

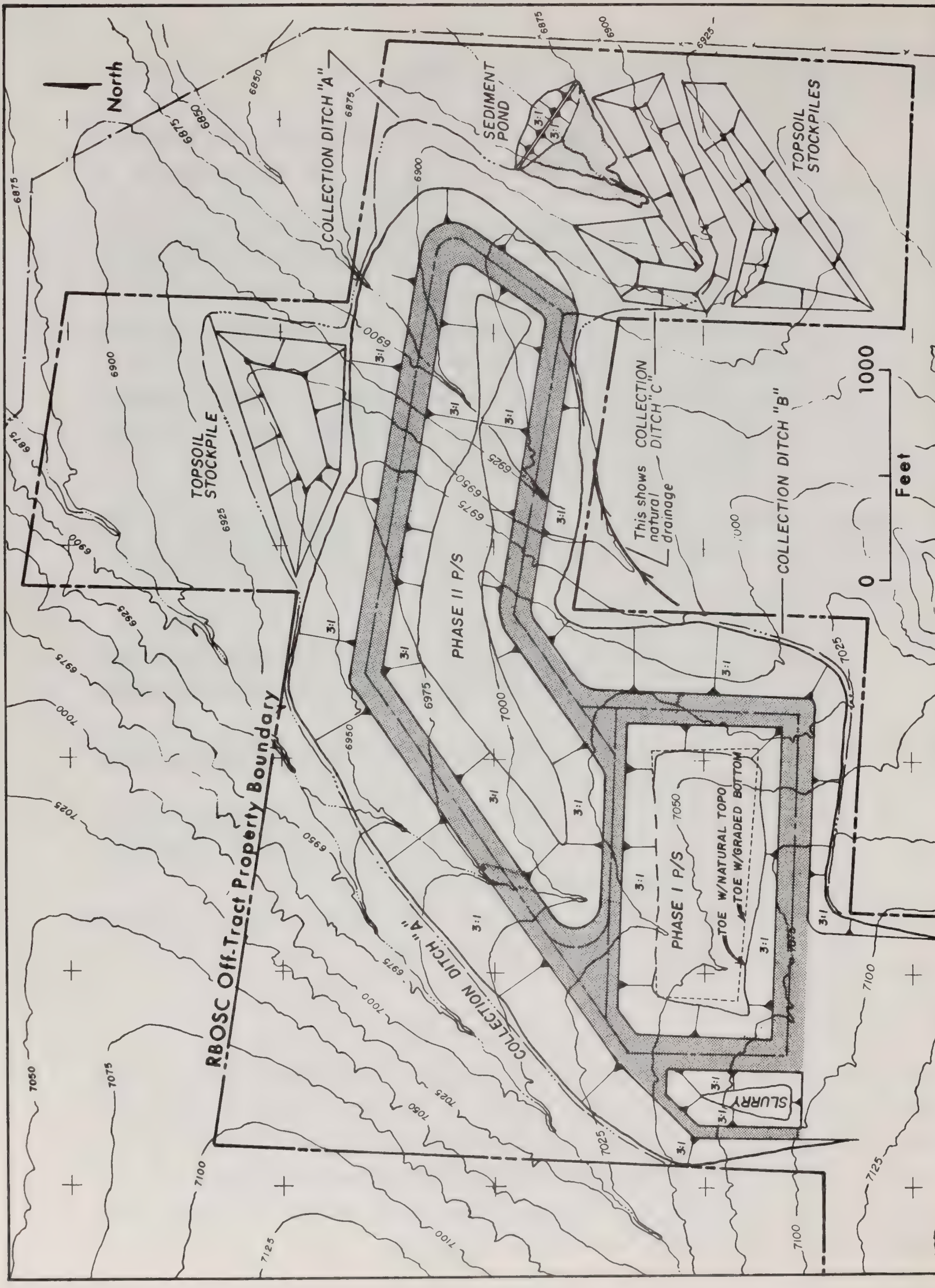



Figure 5.2.9
Processed Shale Disposal System

1. Construction of Containment Facility Dikes - Dikes for the containment facility will be constructed of excess material from the haul road construction and of overburden from the open pit mine. Wide berms with 3:1 external slopes ensure a high degree of stability and erosion protection for the contained processed shale. It is recognized that 3:1 slopes on the external faces of the dikes could be difficult to reclaim. However, the design necessitated 3:1 slopes because of property boundary constraints. If these slopes prove to be impossible to reclaim the slopes will be reduced to 4:1 by narrowing the width of the berm along the top of the dikes. Portions of the overburden constitute low grade oil shale and as such will be classified and placed in defined areas for possible future exploitation.

2. Construction of Leachate Collection System - The Phase I processed shale containment areas will be provided with a total leachate collection system as part of the research design. This comprises a synthetic liner with a filter blanket laid over it. The filter blanket will be comprised of clean washed sand or gravel which will eliminate its potential for altering the chemistry of any leachate which may pass through it. In addition, small berms will be placed in the liner bedding material to segment the lined area, and a system of collector pipes will direct any leachate to individual collector sumps located at the low point of the facility where the leachate will be measured, analyzed and disposed of according to water quality.

3. Construction of Leachate/Revegetation Test Area - The initial processed shale dumping will take place at the east and west ends of the Phase I containment area. The material will be transported from the retort by conveyor and dumped by a stacker in relatively thin layers over the full height of the face. The thickness of these layers will be determined during detailed engineering of the facility. The dumping will take place until there is enough surface area for a revegetation plot area, a flooded induced leaching area, and a leachate control area, plus associated buffers between each. As soon as these areas are complete, the revegetation and leachate demonstrations and research will begin. Prior to and during the revegetation period, wind erosion data of uncovered processed shale will be collected.

4. Slope Stability and Erosion Test Area - The faces of the above areas will be used to perform erosion and slope stability tests on the processed shale material at different slope angles ranging from 1:1 to 4:1.

5. Compaction Test Area - The central portion of the Phase I area will be used to carry out demonstrations of the compaction of the processed shale. The material will be placed and compacted in horizontal lifts and the mechanical and hydraulic behavior of compacted processed shale will be studied.

6. Slurry Testing and Demonstration - Concurrent with the compaction demonstration, a small slurry deposition test will be performed in a special facility to the west of the main Phase I disposal area. This will involve different slurry densities and will be subject to leachate, strength and revegetation research when it is finished.

7. Completion of Phase I Facility - After this sequence is complete, stacking of processed shale will continue in the Phase I containment area until it is filled. A corrugated metal pipe will be placed around the leachate sump areas and extended to surface to maintain access to the leachate collector system after dumping is complete.

8. Phase II - The Phase II system design will be based on the results of Phase I work. In general, it is not anticipated that any Phase II experimental work will be carried out except any follow-up work suggested by the results of Phase I.

## 2.4 SITE PREPARATION AND DIKE CONSTRUCTION

A. On Site Topography and Foundation Conditions - Four small, unbranched tributary streams, flowing in a northeastern direction, cross the RBOSC off-tract property. These streams are normally dry except for storm events or during the snow melt season. The valley areas are covered by bushes and the ridge areas are covered by trees. Average land slope is about 5% with ground elevations ranging from 7,110 feet, north of the Lurgi plant, to 6,850 feet northeast of the RBOSC off-tract land boundaries.

The results of field investigation during early November, 1980 indicate that the area is covered by 0.5 to 3.0 feet of topsoil. Underneath the topsoil is 3 to 15 feet of weathered sandstone which also contains some sandy silt. In the stream valley area, a maximum 18 feet of colluvial silty clay lies between the topsoil and the weathered sandstone.

B. Site Preparation - Prior to dike construction, topsoil will be stripped and stockpiled for reclamation use. For Phase I, the disturbed area is approximately 75 acres, including dike embankment and pond areas but excluding access roads and stockpile areas. Based on the recent field investigation, the total volume of topsoil to be stripped is about 131,500 bcy, which will be stored in segregated piles located on north and southeast sides of the RBOSC off-tract property (Figure 5-2-9). Each pile is about 20 feet high with 4 to 1 side slopes and covers approximately 10 acres of surface area. Topsoil will be spread over the exterior slope of the dike embankment for reclamation once the Phase I dike embankment is completed. Topsoil will also be used for revegetation demonstration programs during the processed shale disposal operation, and will eventually cover the final processed shale surface. To reduce potential for development of erosion channels, runoff from the top of the dike areas will be directed by roadside gutters and drains to the collection ditch at the toe of the embankment.

The bottom of the Phase I containment area will be graded and the leachate collection system will be constructed in such a way as to best incorporate the test program which is presented in Chapter 4 of this Section.

For the Phase II operation, the total additional disturbed area is 85 acres, and approximately 162,200 bcy of additional topsoil will be stripped and stockpiled at the same locations as for Phase I. Details of grading prior to embankment construction will be determined during Phase I. Utilization of this topsoil is the same as for the Phase I operation.

C. Dike Construction - The design layout of the dike is presented in Figure 5-2-9. The maximum dike crest would be at about elevation 7,110 feet, adjacent to the Lurgi process area. The final grade of the Phase I processed shale surface is designed to be 1.7% dipping from west to east. The final grade for Phase II is approximately 8.0% dipping in a northeast direction then 5.5% eastward.

The dikes will be constructed with overburden, end dumped by trucks and spread by bulldozers. During construction a water truck will spray water to control fugitive dust. Total embankment material to be used for the Phase I containment area is estimated to be about 2.9 million bcy with processed shale estimated disposal capacity of 1.37 million cubic yards. Estimated output of processed shale during Phase I is 1.2 million tons. Based on processed shale properties discussed in Part 2.2 it is estimated that the average in-place density of the processed shale will be 65 pounds per cubic foot.

After other construction requirements, 4.0 million bcy of overburden is available for the Phase I dike construction. This is more than required for the Phase I containment area. The excess overburden will be used to construct part of the Phase II dike. The Phase II dike embankment volume is estimated to require approximately 3.3 million bcy of overburden material. This is available from the Phase II operation and the excess overburden left from Phase I dike construction. (See Chapter 3 of this Section). The processed shale storage capacity of the Phase II dike will be approximately 2.0 million cubic yards. The processed shale output from Phase II operation is estimated to be 2.0 million cubic yards (equivalent to 1.8 million tons). The relevant quantities for overburden, processed shale, dike volume, and capacity for the two phases are summarized in Table 5-2-1.

Table 5-2-1

QUANTITY OF OVERBURDEN, PROCESSED SHALE
AND DIKE EMBANKMENT VOLUME

| | Phase I | Phase II |
|---|---|---|
| Overburden available for dike | $4.0 \times 10^6$ bcy(1) | $2.2 \times 10^6$ bcy |
| Processed shale waste | $1.37 \times 10^6$ bcy(2) | $2.05 \times 10^6$ bcy |
| Overburden needed for dike | $2.9 \times 10^6$ bcy | $3.3 \times 10^6$ bcy |
| Dike storage capacity | $1.44 \times 10^6$ cy | $2.06 \times 10^6$ cy |

(1) represents bank cubic yards. A swell factor of 1.35 is used for calculating the volume of overburden needed for the dike.
(2) processed shale density of 65 pounds per cubic foot is used for weight-volume transformation.

A typical dike cross section is shown in Figure 5-2-10. The top widths of the dike will be 150 feet for free-standing perimeter dikes and 100 feet for the dike between Phase I and Phase II. Side slopes will be dressed to a final slope of approximately 3:1 with dike heights ranging up to 100 feet depending on the existing topography. Intermediate benches will be constructed on the exterior slope for the purposes of access, runoff interception and erosion control. The process used to calculate distance between diversion structures on these slopes is presented in Section 7, Chapter 8.3. The top of the dike is designed as an off-highway haul road with berms and ditches on both sides of the road.

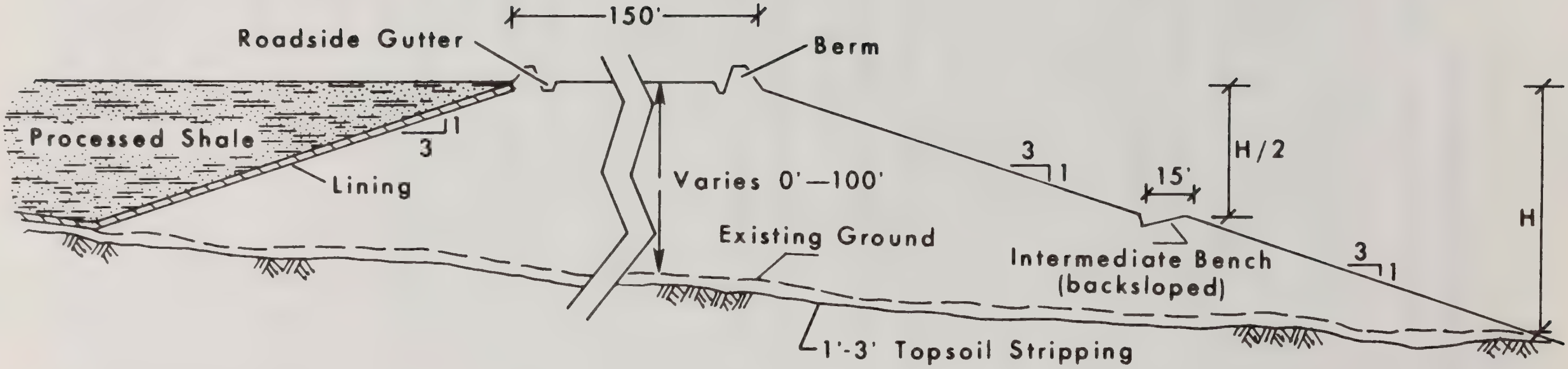
The interior surface of the Phase I containment area will be lined with a synthetic liner such as Hypalon or high density polyethylene to ensure that leachate from the demonstration areas is intercepted for analysis. Also, a ramp along the interior slope will be constructed from crest to bottom for testing and other necessary operations within the containment area.

The results of the leachate and seepage demonstration from the Phase I operation will be used as a basis for final design of the Phase II and for opti mization of an operation.

## 2.5 PROCESSED SHALE CONDITIONING, TRANSPORT, AND PLACEMENT

Processed shale streams from the retorts will be cooled from approximately 1,200°F to about 500°F in a heat exchanger and from 500°F to 200°F in a specially designed cooler. About 17.5% (by weight) of water will then be added for dust control and development of desirable properties such as strength and low permeability. The water for the moisturizer will be provided from the high TDS Lurgi plant waste water or from ground water. The processed shale received from the moisturizer will then be delivered to the containment area by belt conveyor and fed to a belt stacker system.

Layout of the delivery system is shown in Figure 5-2-11. The system will be made up of three components, namely; feeder belt, secondary belt and stacker belt(s). The feeder and secondary belts will be covered for dust control and winter maintenance protection. Provision for addition of water at transfer




Not To Scale

Note: 1. *The Intermediate Benches Should be Placed at Maximum Intervals of 120' on the Exterior Slope*

2. *Dike Crest Width Will be Reduced to Minimum of 100' if the Overburden Material Appears Not Adequate.*

3. *Temporary Acess Road Will be Provided Around Toe of Dike and Confined by Collection Ditches.*

**Figure 5-2-10**
**Typical Dike Cross Section**

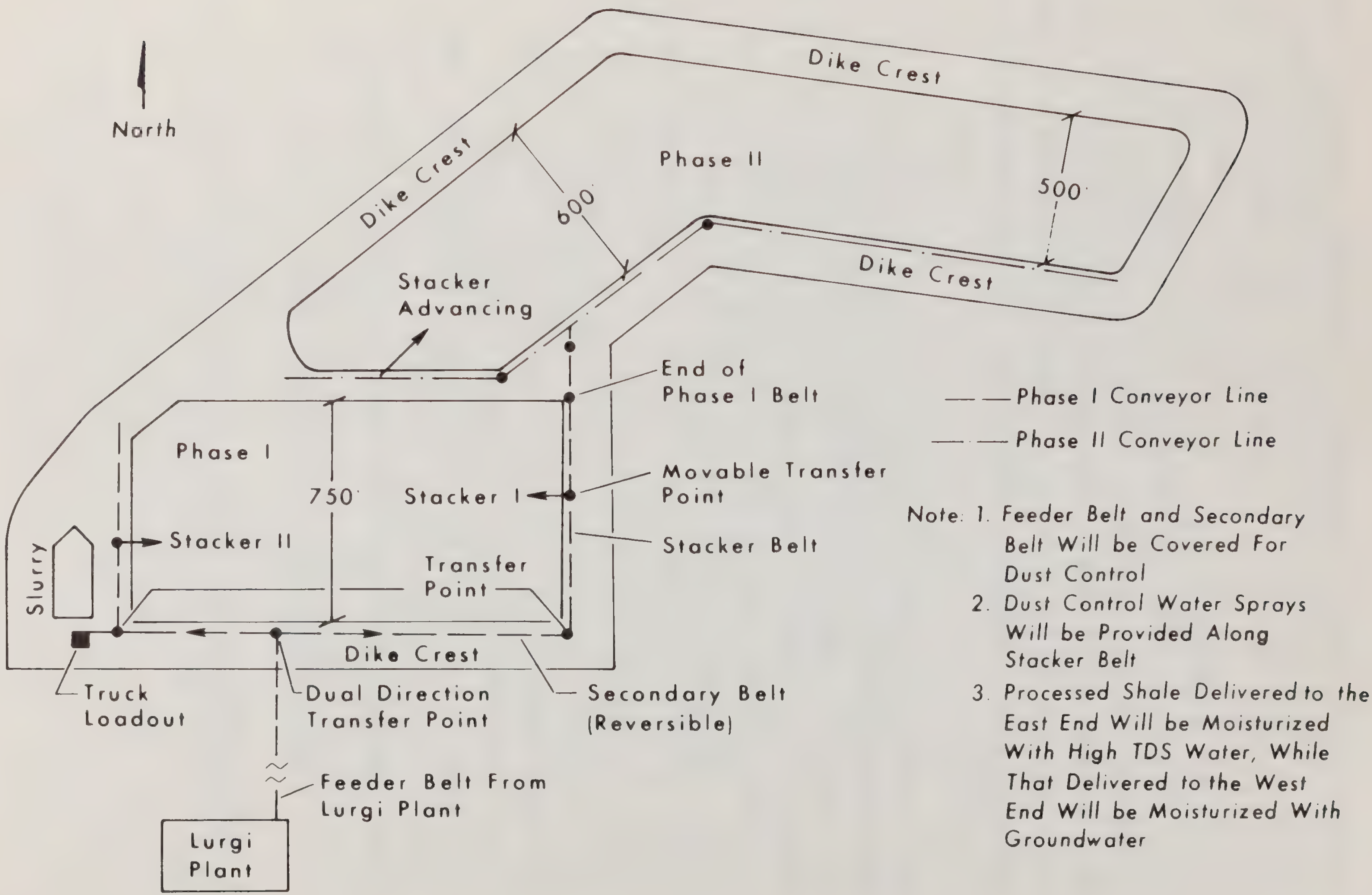



**Figure 5-2-11**
**Conceptual Layout of Conveyor System**

points will be made to compensate for evaporation losses, if required. Stackers will be readily available units. They will be provided with a movable tripper for stacking capability. The processed shale will be deliverable to the stacker on an articulated conveyor which can be constructed in 50 foot sections. Alternatively, radial stackers could also be used and may offer some advantages. For the Phase I operation, the stackers will advance continuously from both the east end of the pond and the west as the processed shale is deposited to the desired elevation. Processed shale delivered to the east end will have been moisturized with high TDS water, while that delivered to the west end will have been moisturized with ground water.

The operation of the Phase I disposal system will be geared to a series of demonstrations related to potential problems with the disposal of the processed shale on a commercial scale. The details of these are discussed in Chapter 4, but in general, the stackers would advance from the ends until sufficient area has been provided for leaching and revegetation demonstrations. Simultaneously, processed shale will be delivered by truck to the central area where the material will be mechanically placed and compacted in lifts. As soon as the leachate test area is ready it will be flooded. Erosion studies will also be carried out on the slopes of the previously stacked material, together with tests on the specially constructed slopes. Following completion of the erosion and compaction demonstrations, the stacker would proceed to fill the balance of the containment area. During this period, a portion of the material would be slurried and pumped to a separate holding pond adjacent to the west end of the pit. Details of the Phase II operation would be based on experience gained from Phase I.

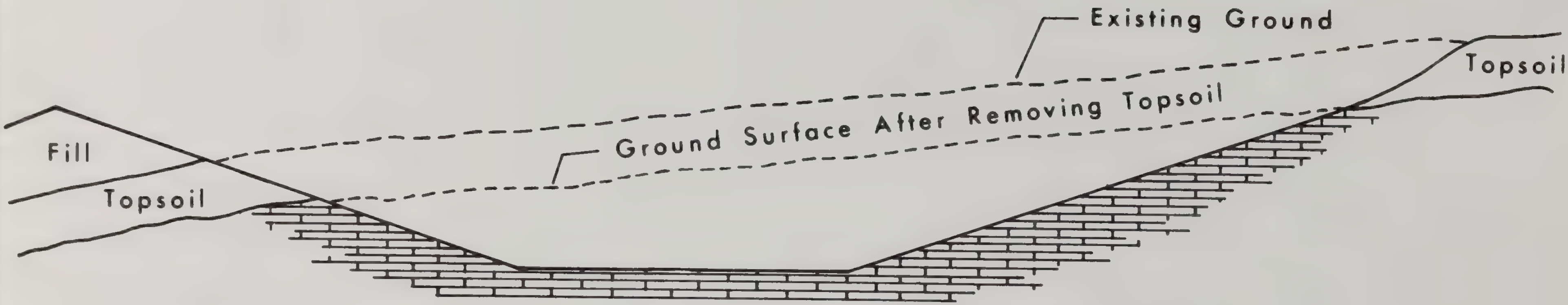
## 2.6 MAJOR EQUIPMENT, STRUCTURES, AND CIVIL WORK

A. Major Equipment - The equipment required for processed shale disposal is summarized by operational function as follows:

- Topsoil Stripping and Site Preparation
  - scrapers
  - dozers
  - graders
  - compactors
  - water trucks
- Dike Construction
  - front-end loaders
  - trucks
  - water trucks
  - dozers
  - scrapers
  - graders
  - specialized liner laying equipment
- Processed Shale Disposal
  - belt conveyor system with stacker
  - truck load-out hopper
  - graders
  - compactors
  - dozers
  - slurry equipment and pipe
- Demonstration Programs
  - pumps
  - irrigation system
  - instrumentation (Chapter 4)

B. Structures and Civil Works - Significant structures necessary for the processed shale disposal facility include dike embankment and water diversion facilities such as collection ditches and the sedimentation pond.

Ditches will be constructed around the processed shale containment area prior to construction to collect runoff from disturbed areas such as dikes, topsoil stockpiles, and covered processed shale fill as shown in Figure 5-2-9. This runoff, excluding runoff and leachate from the processed shale, will be conveyed into a sedimentation pond and then discharged into natural drainageways. A typical collection ditch cross-section is shown in Figure 5-2-12.




Note:

1. Minimum and Maximum Channel Gradients are 0.5% and 6.5%
2. Riprap Will be Provided on Steeper Slopes

**Figure 5-2-12**
**Typical Collection Ditch Cross Section**

Invert profiles for the ditches are shown in Figure 5-2-13. Where required energy dissipaters will be used to control erosion at the outlets of collection ditches.

The sedimentation pond will be completed with energy dissipators on the decant system and emergency spillway. The sedimentation pond will have approximately 6.0 acres surface area with maximum embankment height of about 35 feet and storage capacity of about 37 acre-feet at elevation 6,882 feet. Area/capacity curves are shown in Figure 5-2-14.

The maximum pond embankment cross section is shown in Figure 5-2-15. The embankment will be constructed after stripping of all vegetation and topsoil at the site. Material for the embankment will be derived from the haul road cut and, if necessary, from pit overburden. A downstream toe drain will be provided to control any seepage through the embankment. The embankment design and construction will comply with the regulations of the Colorado Division of Water Resources and design specifications will be developed in the course of doing the detailed engineering.

## 2.7 RECLAMATION

During Phase I, revegetation efforts will be directed toward reclamation of disturbed areas resulting from construction of dikes, ditches, sedimentation pond, and ancillary facilities. When the containment dikes are completed, topsoil will be placed on the exterior slopes and revegetation begun. Small areas of the processed shale disposal pile will be provided for reclamation demonstration during the Phase I operation. The acreage of disturbance for each phase of operation of the processed shale containment is listed in Table 5-2-2.

Table 5-2-2

ACREAGE OF DISTURBANCE DURING EACH PHASE OF OPERATION

| | Phase I | Phase II | Total |
|---|---|---|---|
| Exterior dike slopes | 49.5 | 48.5 | 98 |
| Processed shale surface | 25.5 | 36.5 | 62 |
| Topsoil stockpile | 20.7 | 0. | 20.7 |

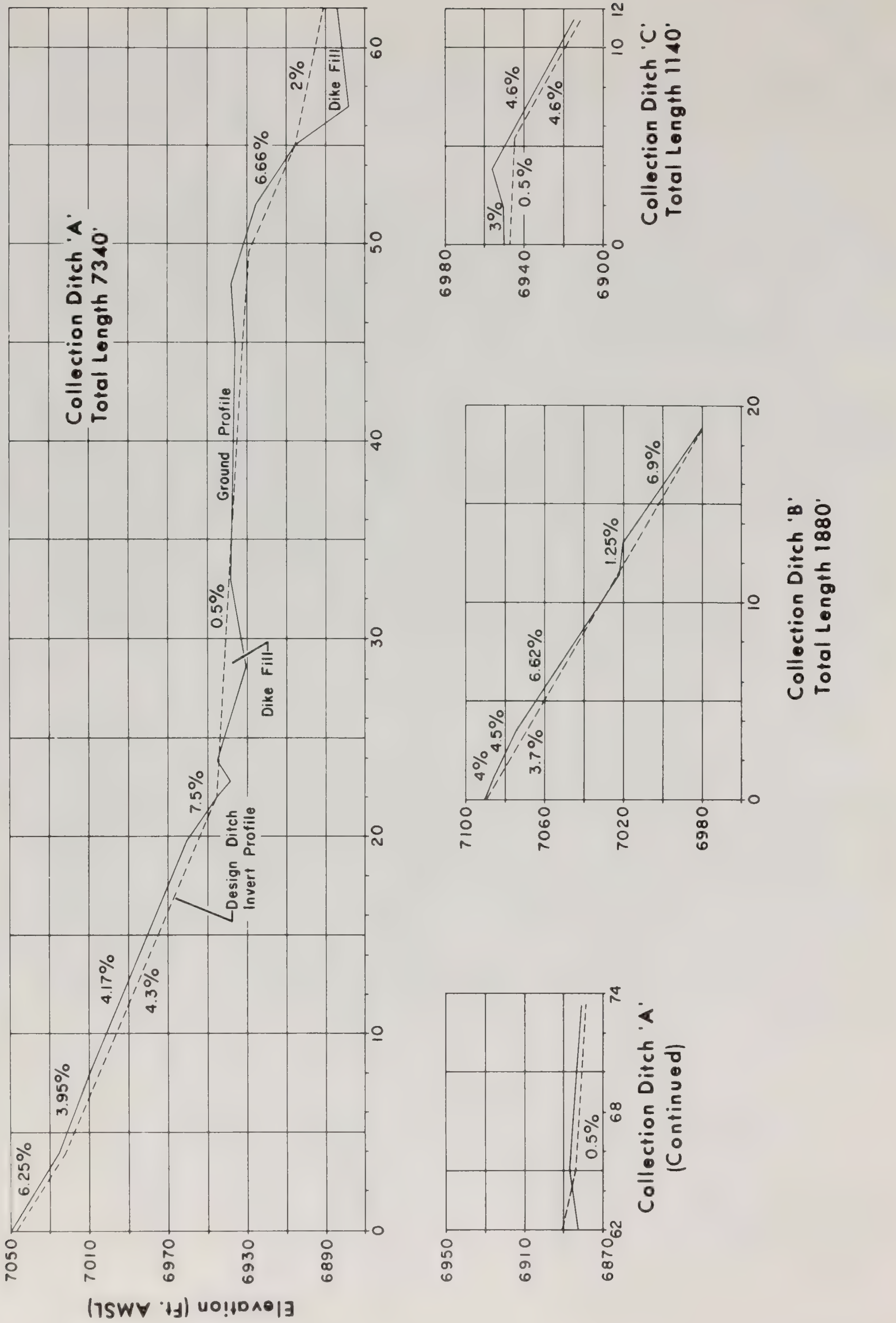



Figure 5-2-13
Collection Ditch Invert Profiles Processed Shale Disposal Area

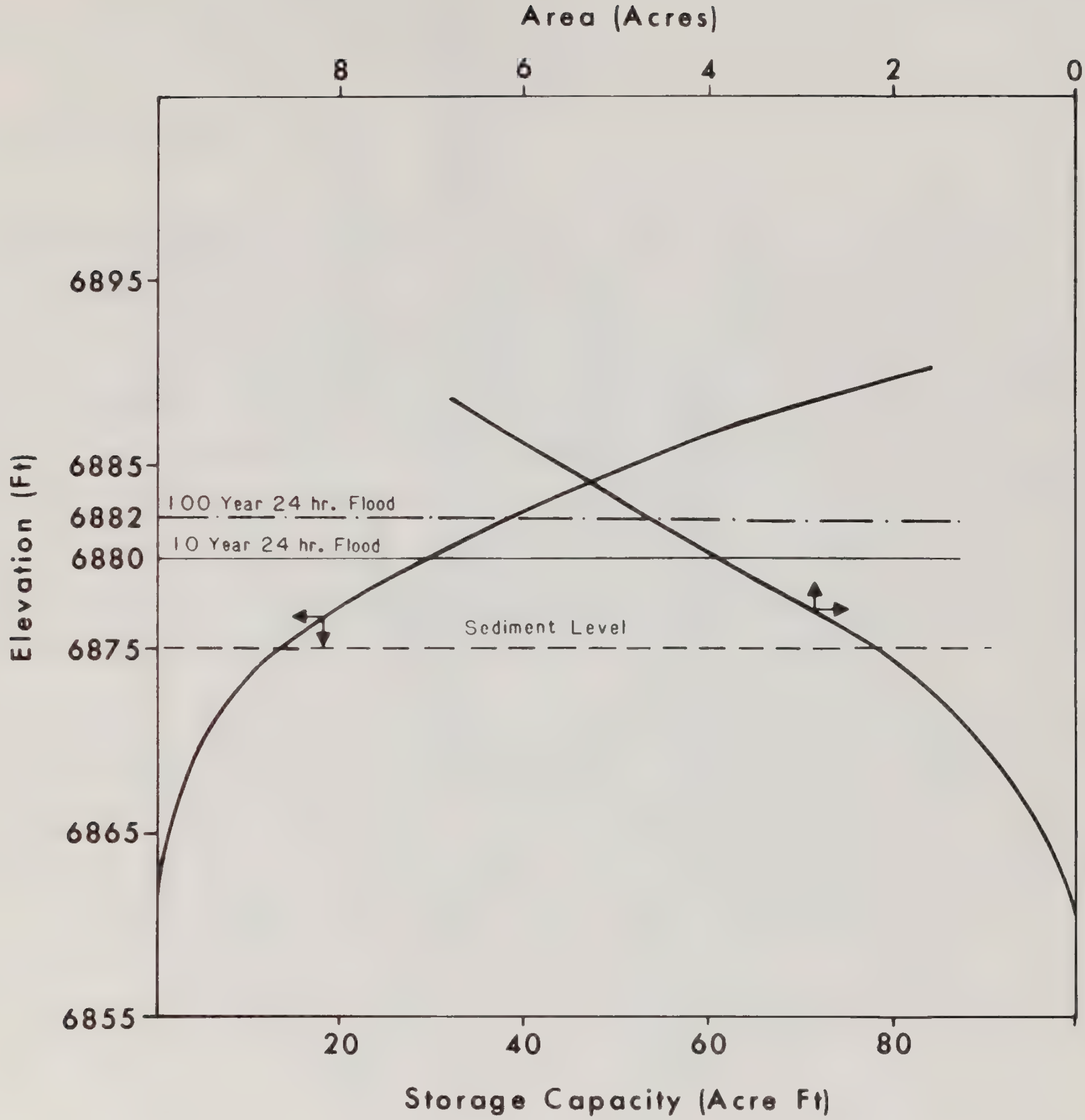



Figure 5-2-14
Sediment Pond Area/Capacity Curves

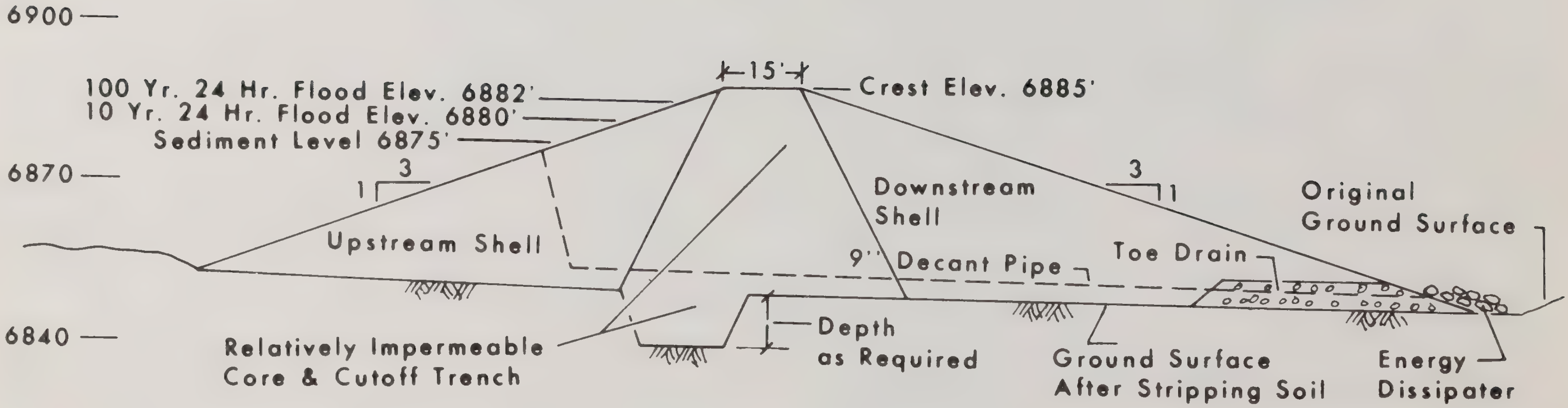



Figure 5-2-15
Maximum Section Sediment Pond

The type of vegetative cover will be in accordance with the regulations of Colorado Mined Land Reclamation (CMLR) and will be selected in consultation with the OSO. For more details refer to Section 7, Chapter 8.

## 2.8 WATER MANAGEMENT PLAN

A. Water Requirements - The major water requirement for processed shale disposal operation will be for moisturization. Other water requirements include dust control during dike construction and processed shale disposal, revegetation and reclamation, testing program, and miscellaneous usage. Based on laboratory studies, it is considered that 15% to 20% water will be required for moisturization of the processed shale. Therefore, the water requirement for moisturization would be 147,600 gpd for the plant production rate of 3,500 tpd of processed shale at 17.5% moisture content. Water will be available from streams coming from the high TDS water at 63,300 gpd and the water supply system at 84,300 gpd assuming 100% operating conditions.

Water for dust control is estimated to be 0.02 gallons-per-square-foot-per-day of disturbed area for the entire Phase I and Phase II operations. A 10,000 gallon water truck making 7-trips-per-day would be able to cover approximately 80 acres. The slurry water requirement is based on a 55% water content in the slurry. Also, the Phase I demon stration programs would require approximately 15 gpm (21,600 gpd) of water for 12 months. Miscellaneous water consumption of 5 gpm has also been assumed. Water requirements have been summarized in Table 5-2-3.

Table 5-2-3

WATER REQUIREMENT FOR PROCESSED SHALE DISPOSAL OPERATION

| | Rates | | Phase I | | Phase II | |
|---|---|---|---|---|---|---|
| | (gpd) | (gpm) | Period (days) | Volume (acre-ft) | Period (days) | Volume (acre-ft) |
| Moisturization | 147,600 | 130 | 300 | 136 | 450 | 204 |
| Dust control | 67,700 | 47 | 180 | 37 | 240 | 49 |
| Testing program | 21,600 | 15 | 365 | 24 | 0 | 0 |
| Slurry water need | 28,800 | 20 | 225 | 20 | 0 | 0 |
| Miscellaneous | 7,200 | 5 | 450 | 10 | 620 | 14 |
| TOTAL | 272,900 | 190 | | 227 | | 267 |

B. Surface Runoff Control - The control of surface runoff in and around the processed shale containment area will be required as follows:

- Surface water derived from the land adjacent to the disposal area
- Runoff from disturbed non-processed shale areas such as dikes and topsoil stockpiles
- Runoff from the processed shale pile

Surface runoff from the north part of the dike will be collected by Ditch A (Figure 5-2-9). Ditches B and C will collect runoff from the south part of the dike and natural drainage runoff. All this runoff will be conveyed to the sedimentation pond located on the east side of the RBOSC off-tract property for sediment removal and discharge. The design criteria for the ditch, sediment pond and embankment are as follows:

1. Collection ditches designed to pass 10-year, 24-hour peak discharge rate.

2. Sediment pond storage capacity designed to store the runoff volume of the 10-year, 24-hour storm and sediment inflow volume of 0.1 acre-feet per disturbed acre.

3. Sediment pond spillway design based on the 100-year, 24-hour storm.

4. Design rainfall values are 1.8 inches and 2.6 inches for 10-year and 100-year, 24-hour storm events, respectively.

During the processed shale disposal period, rainfall and runoff accumulated in the bottom of the containment area will be collected and disposed according to water quality. The pond which will be used for slurry tests near the completion of Phase I can be used as a holding pond during the early part of Phase I. Upon completion of Phase I and prior to reclamation, runoff from the processed shale surface will be collected at the east end of the Phase I surface in a 3-foot deep evaporation pond with one acre surface area. This pond should be sufficient in size to allow for evaporation of most precipitation events. Should excess water accumulate, it will be disposed of according to water quality.

The sedimentation pond discussed in Part 2.6 will have a drainage area of 246 acres. This area will generate 10.7 acre-feet of runoff for a 10-year 24-hour runoff volume and 3.6 AF/Y of sediment volume. The peak flow rate from the 100-year, 24-hour storm event for spillway design will be approximately 196 cfs. The sedimentation pond has capacity to store all the 10-year, 24-hour runoff and 3 years sediment volume plus some surcharge storage for the 100-year event. The sediment pond area capacity curves are shown in Figure 5-2-14.

C. Leachate and Seepage Control - Under normal rainfall conditions, it is not anticipated that there would be any seepage through the processed shale from the surface. In Phase I, however, as previously discussed, there will be sections of the area on which water will be kept ponded in order to induce an artificial seepage through the processed shale. This will afford the opportunity to establish the permeability of the material in-place, and the chemical quality of the leachate. Minor amounts of seepage may also be induced from irrigation demonstration plots and from the evaporation pond at the east end of the containment area. Even under artificial conditions, it may take months or even years for seepage to reach the bottom of the containment area. For example, assuming a permeability of $3 \times 10^{-5}$ cm/sec, it is computed that it would take six months for seepage to extend to a depth of 50 feet under a constant head. As previously discussed, the containment area will be lined so that all seepage from whatever source can be collected and representative samples analyzed. Quantities of leachate are expected to be small. Any excess leachate accumulated during the demonstration period will be placed into an appropriate pond depending on water quality. Upon abandonment, the surface of the area will be regraded and revegetated to minimize the possibility of seepage through the processed shale.

The Phase II design depends on the results of Phase I evaluation. Unless adverse effects are encountered in Phase I, no liner is planned in the Phase II processed shale disposal area for the following reasons:

- Moisture content of processed shale will be optimized so that no leaching will be induced.

- Yearly precipitation is not enough to provide leachate to any significant depth (annual evapotranspiration rate is at least three times the precipitation rate).
- The processed shale disposal pile is remote from the ground water table. RBOSC drilling has determined the ground water level to be 450 to 500 feet below the surface in the disposal area.
- No leachate testing will take place on the Phase II disposal area so a liner is not required to catch any induced leachate.
- Low strata permability will prevent leachate from reaching the ground water level for a very long period of time. Packer testing of the upper strata in the disposal area indicates a permeability of $10^{-5}$ cm/sec.

## 2.9 DUST CONTROL

Dust control methods anticipated in the dike construction and processed shale disposal operation include the following:

<u>Dike Construction</u>

- Water truck watering during the dike construction stage
- Topsoil cover and revegetation on the exterior dike slope, once the dike is completed
- Temporary revegetation on the topsoil stockpiles

<u>Processed Shale Disposal</u>

- Initial moisturization at plant
- Covers on the feeder conveyor belt (and secondary belt)
- Provision for additional moisturization at transfer points
- Provision for additional moisturization at stacker face
- Topsoil cover and revegetation on demonstration areas

The dust levels will be monitored by high volume particulate samplers to ensure that the PSD limits are not exceeded during any of the experimentation or demonstration activities.

# OVERBURDEN DISPOSAL OPERATION

There is approximately 5.2 million bcy of overburden in the Phase I open pit and an additional 4.2 million bcy in the Phase II open pit. One-half million bcy will also be available for construction use from a cut made during construction of the mine haul road to the Lurgi process area. Of the Phase I overburden, approximately one-half of the material is true overburden and the remainder is comprised of low-grade oil shale from the L-8 and R-8 zones. In Phase II, the true overburden comprises approximately two-thirds of the material with the balance being low-grade oil shale.

The open pit will be excavated in 25-foot lifts which will allow segregation of the R-8 zone. The low grade oil shale from the R-8 zone will be used for construction of the processed shale containment dikes and located for potential recovery in a commercial operation.

Most of the overburden excavated during Phase I will be utilized for construction purposes. Following site preparation (clear, grub and remove topsoil), the initial overburden will be used to construct the haul road, mine facilities access road and mine facilities area. Additional overburden will be disposed of adjacent to the haul road and will be utilized as a topsoil storage area. The remaining overburden from Phase I will be used for processed shale dike construction. A summary of the overburden disposition for Phase I is given below:

| Overburden Available | Million bcy |
|---|---|
| Phase I open pit | 5.2 |
| Haul road cut | 0.5 |
| | 5.7 |
| **Overburden Used** | |
| Haul road and mine access road construction, topsoil storage area, mine facilities area | 1.7 |
| Phase I processed shale dike | 2.9 |
| | 4.6 |

The Phase II processed shale dike requires about 3.3 million bcy of overburden for construction. Since 1.1 million bcy is available from Phase I construction (5.7 MM bcy - 4.6 MM bcy), one third of the Phase II dike can be constructed during Phase I.

Due to the limited area available on the RBOSC off-tract property a portion of the overburden from Phase II will be disposed of on-tract. Phase II overburden will initially be disposed of in the gulch immediately southeast of the open pit on the south side of Dry Fork (East Gulch). Prior to disposal in East Gulch, the area will be cleared and grubbed, and topsoil will be removed and stockpiled immediately south of the pit. A side cast haul road will be constructed along the west side of East Gulch. For more details on the haul road refer to Section 2, Chapter 6C. In Phase II a total of 4.2 million bcy of overburden will be excavated from the open pit. Of the total, 2.2 million bcy will be used to complete construction of the Phase II dikes and the remaining 2.0 million bcy will be disposed of in the East Gulch.

The 138 KV powerline will be relocated south of the disposal area. A sedimentation pond will be built in 1982 to divert runoff around the open pit; it will also collect runoff from the topsoil stockpile and the East Gulch fill. For details on the sedimentaion pond refer to Section 7, Chapter 6. The depth of the fill in the East Gulch will range from 0 to 150 feet.

The outer slopes of the East Gulch fill will be established at the angle of repose and the surface of the fill will not be revegetated for the following reasons:

- o The life of this stockpile, before being returned to backfill the pit, is less than two years.
- o Surface water runoff will have sediments removed prior to discharge into the natural drainage.
- o Coarser material will be dumped on the outer slopes to minimize wind erosion.

## 4.1 GENERAL

The intent of the demonstration program will be the large scale evaluation of some of the factors which are important for optimizing the operation of a commercial facility. From a consideration of mining, processing, and regulatory priorities, the following variables have emerged as both important and capable of evaluation during the demonstration program:

- Leaching characteristics: A major concern in the disposal of the processed shale is its susceptability to leaching by percolating water and the quality of the water which might be produced by leaching. A significant portion of the demonstration disposal program will therefore be devoted to the investigation of this concern. An important aspect of the investigation will be to determine the effect of moisturization water quality on leaching characteristics and other properties. Separate areas of the disposal facility will accordingly be devoted to processed shale moisturized with ground water and with high TDS process water.
- Stability: The in place stability of the disposed shale is also of major concern. In this context, stability includes resistance to erosion by wind and surface water as well as resistance to mass instability. During the demonstration program, wind erosion will be monitored and investigations of surface water erosion will be performed on a variety of exposed slopes within the processed shale containment area. Although some direct observations of slope stability may be possible during the stacking process, it is concluded that this problem will have to be investigated indirectly. This will be done by determining appropriate properties through in situ testing and laboratory testing of undisturbed samples obtained from the deposited processed shale.
- Revegetation: A critical variable in processed shale disposal is the revegetation of the surface of the pile. The program designates test

areas for revegetation available early in the life of the project in order to maximize the growing time on test plots. Additional areas become available as the project progresses.

- Materials handling: A belt stacking system was selected for deposition of the processed shale. This choice, in part, was made because of the systems suitability for the demonstration program and in part because conveyors are a likely candidate for use in the commercial operation. Systematic observations of performance will be made during the course of the program for application to the design of future systems. Trafficability of equipment on the processed shale pile surface will be an important aspect of the demonstration operation.
- Compaction characteristics: Density of processed shale affects its permeability, strength and volume. Various methods of compaction can be used to vary density. Therefore, an area of the processed shale disposal facility has been set aside to determine the compaction characteristics of the material and the resultant properties of the compacted processed shale.
- Slurry deposition: The characteristics of the processed shale make it attractive to consider transport and deposition in slurry form. Although the inherent disadvantages of this method make it unlikely that it could be used extensively at a commercial scale, a small containment area has been set aside outside the main facility to investigate the properties of slurry-deposited material. Lurgi processed shale slurry backfilling studies are also being considered by the U.S. Bureau of Mines.

The approach used in the design of the demonstration program has been to develop a relatively few test areas of reasonable size in order to keep the testing or demonstration of the above variables as simple as possible. Direct evaluation of prototype systems has been proposed wherever possible. In keeping with current regulatory trends, test instrumentation will be simple and is designed to produce unambiguous results.

A total of five specific test areas have been defined for the program. Timing of each test will be determined in the course of completing the detailed engineering. As timing details are developed they will be submitted to the OSO. The test areas are shown in Figure 5-4-1 and are described briefly below.

- Area 1: This area will be filled with processed shale moisturized with high TDS process water. It will be end-dumped in a single lift using a belt stacker unit.
- Area 2: This area is similar to Area 1, except that it will be made up of stacker-dumped processed shale which has been moisturized using ground water.
- Area 3: This is the compaction test area. The compacted material will not fill the area, and when testing is complete this will be filled to capacity with end-dumped processed shale.
- Area 4: This area has been set aside for erosion testing. The slopes chosen are 1.25:1 (angle of repose), 2:1, 3:1 and 4.1. These latter slopes will be created using earthmoving equipment, and erosion tests will be performed on them. This area will also be backfilled after testing is complete.
- Area 5: This area has been set aside for testing processed shale slurry. It is entirely separate from the main moisturized processed shale disposal area.

When the facility is complete, all test areas will have been filled to grade, revegetated in various ways, and fully reclaimed. There will be very little surface evidence of the wide variety of tests which have been performed.

4.2 LEACHING

A. <u>General</u> - Leaching tests for four materials will be conducted during Phase I. These will evaluate the gross permeability and leachate quality derived from:

- Stacked processed shale moisturized with high TDS water (Area 1)
- Stacked processed shale moisturized with ground water (Area 2)
- Compacted processed shale (Area 3)
- Slurry transported processed shale (Area 5)

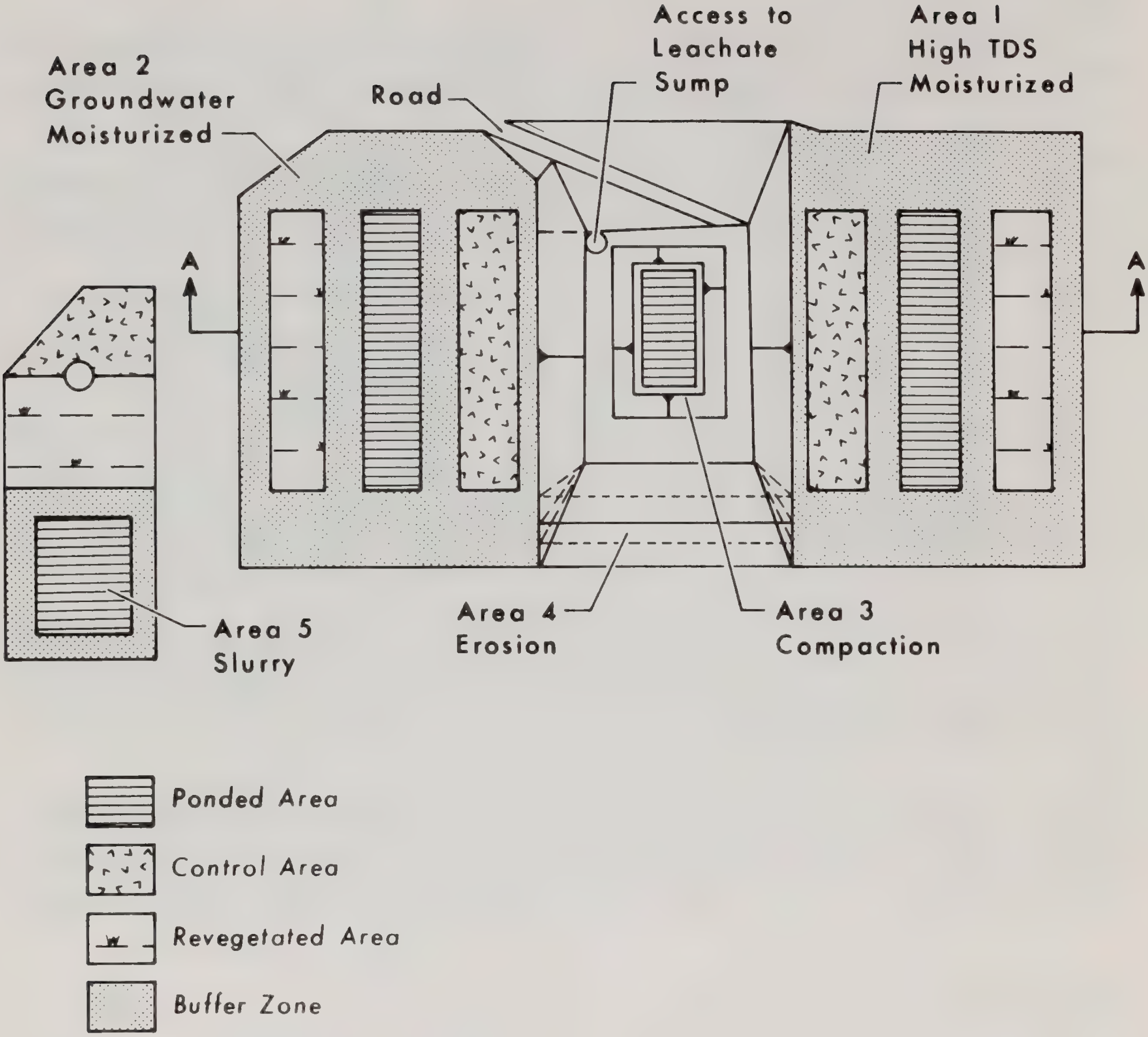



**Figure 5-4-1**
**Layout of Test Areas for Phase 1**

The plan for the leachate test is to incorporate the elements listed below into the processed shale:

- Pond
- Instrumentation
- Leachate collector system

Alternatives will be considered to obtain results prior to the design of the Phase II processed shale disposal system.

In addition to an active ponded area, each test will have a corresponding control area which will be identical except that no artificially supplied water will be ponded on the surface. Instead, natural precipitation will be allowed to pond and infiltrate to simulate actual commercial conditions.

B. Ponds - The ponds will be uniform depth and will be kept full at all times. They will be supplied with water of constant quality, and water will be recirculated to the plant through the pond in order to ensure that the quality of water within the pond is not modified by evaporation. Ground water will be used to fill the ponds, for the following reasons:

- The largest potential cause of environmental degradation due to leachate in a commercial facility would be ground water flow through mine backfill processed shale, rather than from infiltration of incident precipitation. Therefore, it is desirable to model this condition.
- The quality of the pond water is easiest to maintain using the ground water which is subsequently consumed in the plant system.
- The use of collected rain water or tertiary treated water as a leaching medium would probably produce leachate of better quality than would be obtained using ground water. Because this would be unconservative in the sense that the worst result might not be produced, it was considered prudent to use ground water.

Ponds will be recessed into the processed shale pile, and will be a minimum one foot deep, except for the compacted processed shale pond, which will be ten feet deep. An allowance of one foot of freeboard will be made. To avoid any potential instability of the shale pile, ponds will be filled only after the shale pile crest has extended more than 100 feet from the crest center line of the pond. This restriction can be relaxed in the case of the compacted shale pile. Finally, the pond will extend only over full depth material. The surface above the sloping sides of the containment dikes will be left without pond cover in order to avoid "short circuiting" the system.

C. Instrumentation - Instrumentation in the processed shale is designed to monitor the movement of wetting fronts through the pile, and the physical and chemical changes in the leachate and the shale which may occur during the leaching process. Three types of instrumentation are presently envisaged, although other forms of monitoring may be used as well.

- Piezometers: A vertical series of piezometers will be installed to measure any head build-up in the shale material.
- Lysimeters: A vertical series of lysimeters will be installed to collect leachate samples from intermediate positions in the pile, and to positively identify the passage of the wetting front.
- Neutron Test Holes: The presence or absence of saturation can be detected by measuring the neutron absorption and reflection capability of the medium. As a test of this technology, repeated neutron surveys will be taken in cased holes located in the processed shale to identify the progress of the wetting front.
- Precipitation gauges and evaporation pans
- Quantity of water ponded will be recorded
- Evaporation loss from ponds will be calculated and recorded

The location of all measuring equipment will be decided after consultation with the OSO.

In addition to this nondestructive testing it is proposed to periodically drill test holes in the processed shale pond areas to obtain core of the processed shale material. Among other things, the degree of saturation and chemical variables will be tested at various depths. Holes will be backfilled to prevent them from becoming conduits for accelerated leaching.

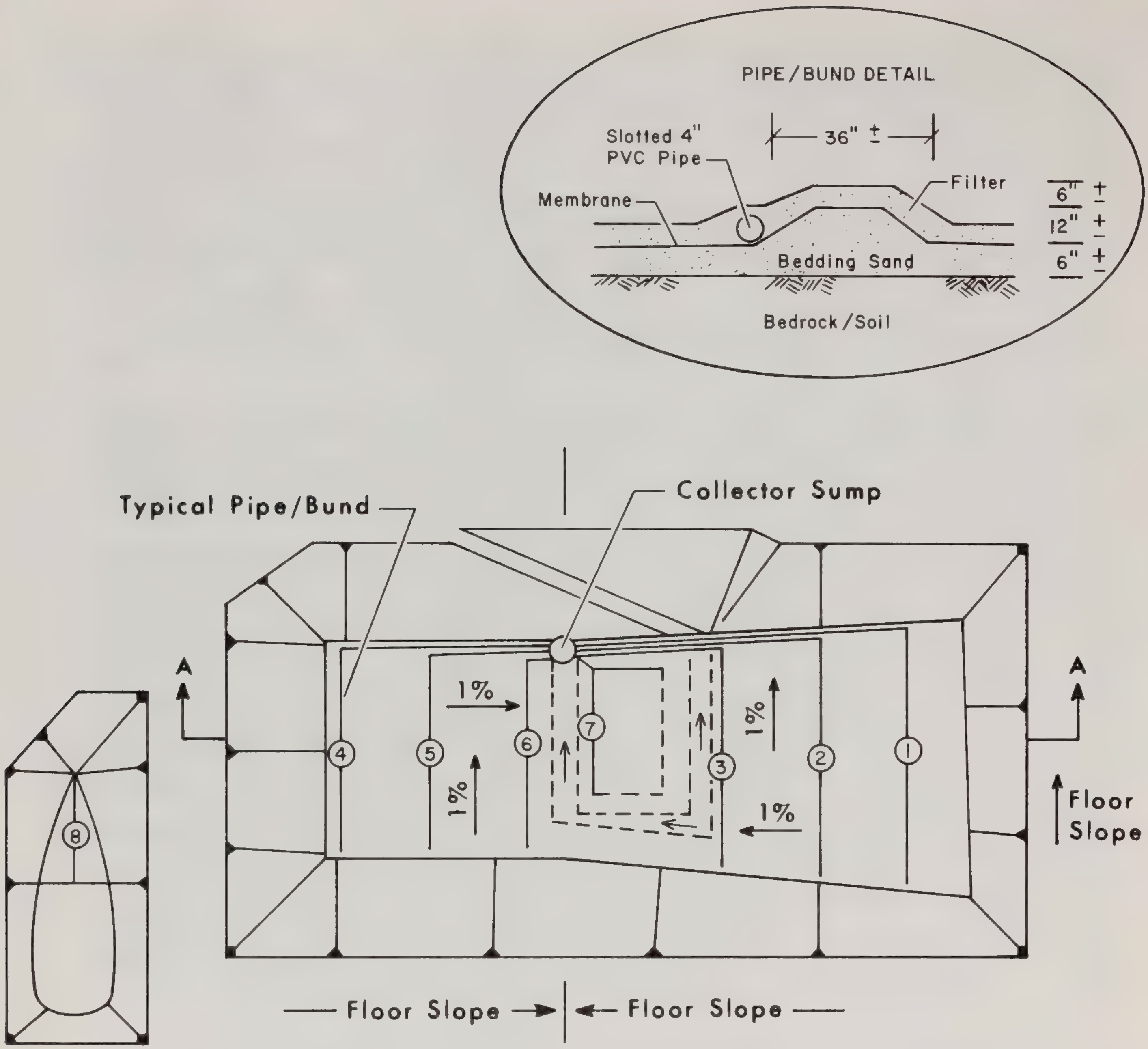
D. Leachate Collector System - In order to ensure that the maximum amount of leachate is available for testing, and that an accurate measurement of leachate flow is made, all of the leachate which exits the base of the pile will be collected. In order to do this, the demonstration facility will be entirely lined with an impervious membrane liner, and the lined pond will be segmented by bunds (embankments used to control the flow of water) and individual collector pipes. In this way, leachate from each demonstration area can be individually collected and monitored.

The leachate collection system operates entirely under gravity flow. Leachate is collected from the various segmented areas by slotted PVC pipe which is placed immediately upstream of low bunds on the floor of the facility. Details of these bunds and of the pipe locations are shown in Figure 5-4-2. The impervious liner is laid over the bunded material. The slotted collector pipe is laid on top of the liner, and a layer of filter sand is then placed over both. The sand serves as both a filter and as a conduit for gravity leachate flow to the collector pipe. Each leachate collector pipe is routed to the northern side of the facility floor, and then through the separating bunds west or east to a central collector sump. Here, individual leachate samples (if any occur) will be collected in separate containers. As the pile builds up, the sump will be protected by a large diameter corrugated metal pipe placed vertically, and built up with the pile. This will become a permanent access manway for the final facility, and will allow continuous sampling and inspection of the leachate collection system.

The leachate will be collected and measured and representative samples tested at a certified laboratory for inorganic, organic, and toxic substances including carcinogens.

E. High TDS Moisturized Processed Shale Leachate Test - The test of stacked processed shale moisturized with high TDS water will take place in Area 1 (Figure 5-4-1) at the east end of the Phase I facility.

The water used for moisturizing in this case is primarily concentrated ground water obtained from the water treatment facilities. It will be desirable to use water of this quality to moisturize processed shale in a commercial facility if it can be shown to be environmentally acceptable.




<u>*Pipe Legend*</u>

1. *Revegetation - High TDS*
2. *Pond - High TDS*
3. *Control - High TDS*
4. *Revegetation - Groundwater*
5. *Pond - Groundwater*
6. *Control Groundwater*
7. *Compaction (---- Indicates Bund Only)*

→ *Surface Runoff-Faces & Erosion Tests*

8. *Pond Slurry*

*Note: Section A-A Shown on Figure 5-4-3*

**Figure 5-4-2**
**Layout of Pit Bottom & Leachate Collection System-Phase 1**

Stacking will progress to the west, producing a somewhat layered material with a dip of about 35° to 38° to the west. It is anticipated that leachate will percolate along coarser planes at this dip. Accordingly, the eastern collector system bund is located directly beneath the eastern leach pond embankment, but the western collector bund is located down dip at 35° to the west of the center line of the western leach pond embankment.

The instrumentation for this pond is planned for a location just inside the western embankment of the pond. This will allow intersection of the full section of the processed shale and even at the base of the pile the instrumentation will be within the material which "outcrops" in the pond area.

This leachate test unit will be the first to go into service, as high TDS water will be available early in the processing. Thus, it is a critical test area, and may be the only area which produces any significant quantity of leachate within the Phase I test period.

Associated with the ponded area will be a control area, located 100 feet to the west of the ponded area. This will be identical to the ponded area with respect to construction, but will not be filled with water except by direct precipitation. Instrumentation and leachate collection will also be identical. This area will more realistically analog field leachate performance in a commercial facility.

F. Ground Water Moisturized Processed Shale Leachate Test - The test of stacked shale moisturized with ground water will take place in Area 2 (Figure 5-4-1) at the west end of the Phase I facility. This water would be used for moisturizing if it is demonstrated that high TDS water is environmentally unacceptable, or if no high TDS water is available. The testing of leachate from this area is therefore important, but not as important as from the high TDS moisturized area.

The entire facility is a mirror image of the high TDS moisturized processed shale test area, and is identical except that the average thickness of processed shale is somewhat greater (60 feet compared with 45 feet), and the time of operation will be somewhat less.

G. Compacted Processed Shale Leachate Area - Compaction of processed shale will decrease its permeability. In order to increase the potential for obtaining leachate through the compacted processed shale during the Lurgi demonstration project it is proposed to:

- Shorten the leachate path--to ten feet, which is between four and six times shorter than in the stacked shale tests
- Raise the driving head--by deepening the pond to ten feet, which gives approximately twice the gradient that will exist in the stacked shale tests.

The result of these two changes is to reduce the time for percolation by a factor of between 8 and 12, which will hopefully at least partly compensate for the reduced permeability of the medium.

Because of the space taken up by the embankments which impound the ten feet deep pond in this test there is no control area. The total compaction test area is about 1-1/2 acres, of which about half an acre is ponded. Instrumentation will be similar to that used in other leach tests, except that only a single piezometer and lysimeter will be used due to the small depth of processed shale.

After all other processed shale areas are completed, the volume above and beside the compacted shale area will be backfilled using the spreader system.

H. Slurry Transported Processed Shale Leachate Area - The slurry transported processed shale leachate test area (Area 5, Figure 5-4-1) will be a small scale analog of the "dry" disposal areas. It will contain a segmented leachate collection system, a ponded area and a control area.

## 4.3 ENGINEERING PROPERTIES

A. General - The behavior of large processed shale piles has not been extensively evaluated because of the lack of sufficient processed shale. The RBOSC facility offers the first major opportunity to evaluate the engineering behavior of processed shale at a scale approaching commercial. The tests presently envisaged include evaluation of:

- Erosion
- Compaction
- Slope stability
- Settlement

The approach to testing will in all cases, be to relate results to laboratory property tests of the material, so that scale-up of performance can be made should later process modifications occur which might invalidate the demonstration scale tests as prototype. Primary variables which are expected to influence behavior and which will therefore be carefully monitored are:

- Grain size
- Pozzolanic activity
- Moisture content
- Quenching/moisturizing history
- In situ density
- Temperature history

The first two variables are largely fixed for a given process, while the last four variables can be modified to achieve a desired result within fairly wide ranges.

B. <u>Erosion</u> - Wind and water erosion will be evaluated by direct testing of slopes within the test area. The performance of dumped faces (angle of repose) will be tested at the edges of Test Area 1 and 2. In addition, processed shale slopes of 4:1, 3:1 and 2:1 will be constructed on the south side of the facility using dumped and graded material, as shown in Figure 5-4-1.

Wind erosion will be evaluated by exposure over a long period to the prevailing winds. Particulate monitoring and physical measurements of material removal will provide complementary data on the influence of slope and aspect on erosion.

Water erosion testing will be undertaken by sprinkling the face of the pile with water at rates corresponding to major storms and sustained rainfall. Data obtained will be used to calibrate the universal soil loss equation for this material. This data will be of considerable use in planning sediment removal and handling systems in a commercial facility. Gullying or channeling will also be studied by directing sustained localized flow down the slopes. All water which runs off the slope during these tests will be captured, measured, and sampled for quality. This data will allow calibration of a runoff equation for commercial facilities, and evaluation of runoff quality which will be important in a commercial operation.

C. Compaction - In order to determine the physical properties of processed shale in the context of a commercial operation RBOSC will simulate those properties in this demonstration program. An important variable which affects the strength, permeability and volume of processed shale in the laboratory is its density. To simulate the density of the processed shale in the large backfills contemplated in a commercial operation various methods of compaction will be tested. Specific compaction evaluations planned for the demonstration program are:

- Self Compaction: The pile will have processed shale depths from 0 to 60 feet which will be loose dumped from a stacker. It is proposed to directly measure densities achieved by self compaction and extrapolate these results to the higher commercial processed shale piles.
- Impact Compaction: A common method of increasing compaction using a stacker is to increase the drop height and hence increase the dynamic compaction effect. If space allows, it is planned to test this effect by varying drop height (dust generation will also be simultaneously measured - see below).
- Mechanical Compaction: A number of mechanical compaction methods will be tested in the construction of the compaction leachate test area, including vibratory, sheepsfoot, and smooth rollers, rubber tired vehicles, and tracked vehicles.

Results in each case will be assessed against standard laboratory and field compaction tests to allow calibration and scale-up.

D. Slope Stability - As the highest slope to be constructed in Phase I of the study will be only 60 feet, the likelihood of obtaining useful direct slope stability information for commercial sized slopes is remote. Therefore, the method of investigation for slope design parameters will be to take undisturbed samples of processed shale from coreholes in the full range of material placed in the facility. These samples will then be tested to produce the necessary design strength parameters.

In addition, if feasible, in-place testing of the processed shale will be carried out using such devices as cone penetrometers and pressure meters. By carrying out this work at intervals throughout the demonstration program, the gain or loss of strength with time will be evaluated.

E. Settlement - The ability to predict settlement which will result from full scale processed shale piles is important because of the impact that settlement can have on final landforms and drainage patterns. It is also of importance if structures are to be placed on the processed shale.

The field observation of settlement will be performed using surface survey hubs and settlement plates located at various depths in the processed shale, as shown schematically in Figure 5-4-3. To complement the results from a number of such installations, core samples will be subjected to consolidation testing in the laboratory. The comparison between predicted and measured settlement may allow a calibration of the laboratory results which will aid in future design. An attempt will be made to measure changes in settlement behavior as the material ages.

## 4.4 OPERATIONAL BEHAVIOR

The demonstration operation gives an excellent opportunity to evaluate the operational behavior of the processed shale with respect to handling, trafficability, dust control and revegetation.

A. Materials Handling - The requirements of the demonstration project to handle the processed shale provide an opportunity to evaluate the materials

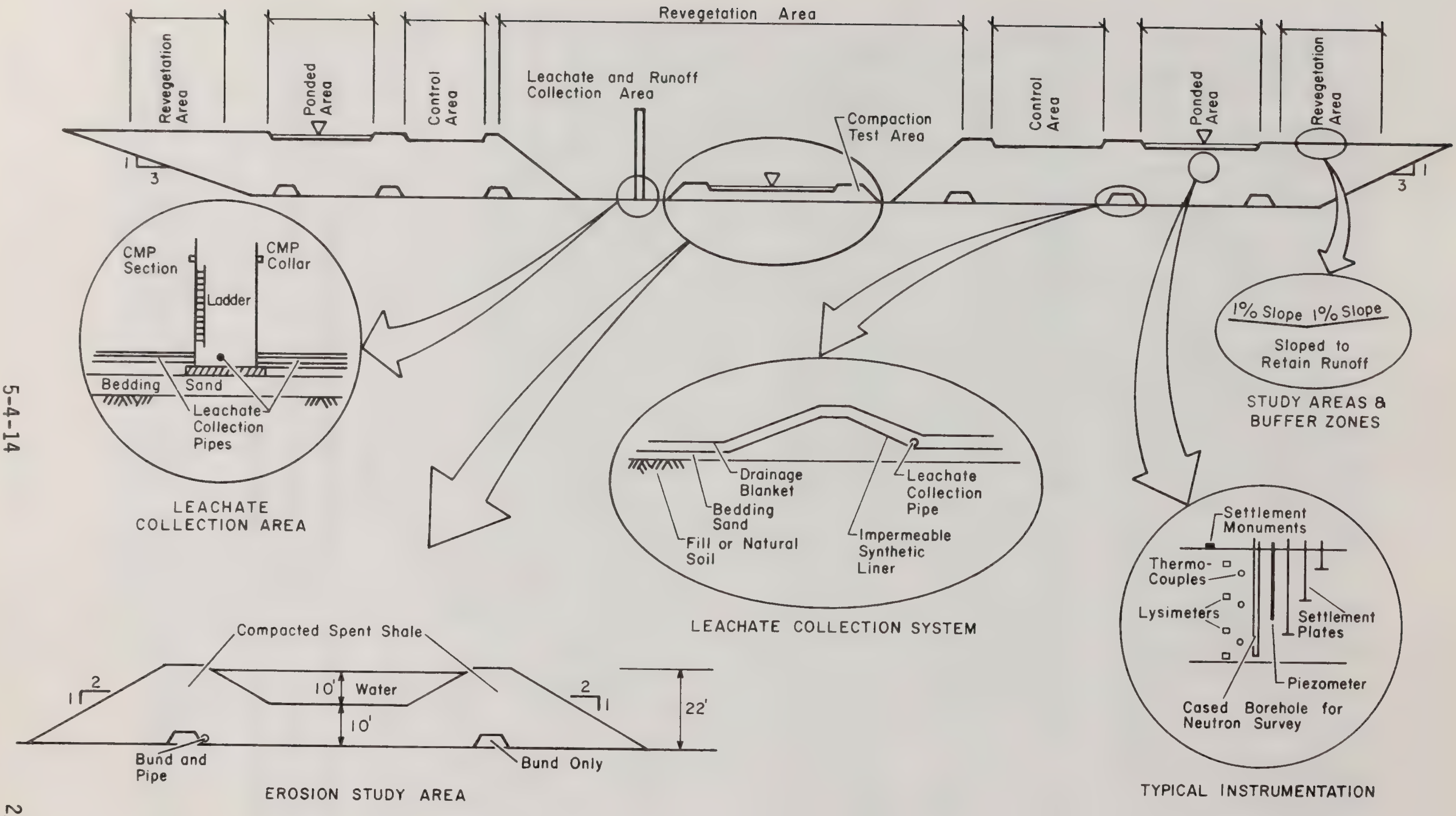



Figure 5-4-3
Sections Through Phase I Demonstration Shale Pile

handling problems associated with processed shale. The following transport systems will be used and their effectiveness assessed.

- Conveyor/Stacker: This is the primary method of transport presently proposed for the processed shale facility. An enclosed conveyor system leading to two small stackers is planned. All aspects of the system performance will be monitored including belt life, material build up, system reliability, dust generation, fire prevention and processed shale watering.
- Truck and Scraper: The compaction test area will be installed using truck haulage and possibly scraper placement. This will allow determination of the effectiveness of wheeled transport systems for processed shale.
- Slurry: The inclusion in the program of a slurry test area also provides an opportunity to assess the materials handling characteristics of the slurry within the constraints of a small system.

In all cases, the material being handled will be characterized by laboratory testing of periodic samples from the discharge of the Lurgi plant and from the discharge of the transport system. These samples will be tested for grain size, moisture content, pozzolanic activity, temperature and some mineralogical parameters. Raw shale samples will be tested for some mineralogical parameters. This will allow correlation between material type and handling performance. In addition, the output rate of the plant will be measured and the total flow accounted for in the disposal area.

Some experimentation is anticipated particularly with respect to moisture content. While the scarcity of available water suggests that moisture content of the processed shale should be kept low, the materials handling constraints require a high moisture content. This variable will be studied with care.

B. <u>Trafficability</u> - The trafficability of unprotected and protected Lurgi processed shale surfaces is not presently well known. As a great deal of heavy equipment and vehicular traffic will operate on the processed shale pile in a commercial operation it is essential that the feasibility of movement across different processed shale surfaces is evaluated in order to include required surface modification or armoring in commercial scale designs.

The performance of vehicles and equipment on processed shale surfaces will be investigated with the respect to the following parameters:

- Bearing capacity
- Wear characteristics
- Dust generation
- Performance during precipitation
- Freeze-thaw performance

Four classes of processed shale surface will be investigated during the program:

- Loose dumped: This is the processed shale placed by the stacker without any surface preparation. Clearly, trafficability on this material is critical for stacker design, and for conveyor moving equipment. However, if it could be shown that trafficability was not a major problem on this loose material, then substantial savings could be realized in a commercial operation.
- Compacted: Compacted processed shale should behave better as a traffic surface than loose dumped. The compaction test area will be used for vehicle tests and for standard field and laboratory bearing and performance tests. Different compaction methods and compactive efforts will be tested.
- Slurry Deposited: Processed shale slurry conditions represent a special case of potential trafficability problems. Data is needed on the time and treatment necessary before vehicles can move across a completed pond area. Tests will be carried out on the slurry disposal area and will be conducted on a "design-as-you-go" basis.
- Paved/Armored: The approach to testing road design for processed shale will be to perform the standard tests on the material and to design a series of road segments. These segments will then be built and traffic tested with design equipment loadings.

These tests should allow design of haul roads, equipment and off-road access on processed shale piles for a full scale facility.

C. Dust Generation and Control: The generation of dust from shale disposal activities will be investigated. Detailed research of dust generation and control will be concentrated in three areas:

- Wind Generated Dust: The influence of slope angle, aspect, and processed shale properties on wind generated dust will be investigated in the facility. The two main faces of the disposal piles face east and west, and the prevailing wind is from the southwest. Thus, a wide range of combinations of wind direction and slope aspect should be possible.
- Materials Handling Dust: The major potential dust generator is the processed shale handling system. As noted above, several systems will be tested during the demonstration operations, and a range of experiments on dust generation and control will be performed. Monitoring of conveyor transfer points, stackers, sprays, bag houses, and other equipment will provide performance data which will allow commercial equipment design optimization for minimum dust emissions.
- Traffic Generated Dust: The dust generated by traffic depends on a range of variables including pavement type, vehicle type, speed, and ambient conditions. During the pavement and trafficability tests, dust generation and mitigation studies will also be undertaken to provide input into future permitting of equipment and health studies.

Control and generation of dust are very much governed by processed shale moisture content. A significant use of water in a commercial sized mine will be for dust control. This segment of the demonstration program is designed to define the minimum amount of water needed to meet acceptable dust standards in a commercial operation.

D. Revegetation - In order to reclaim processed shale disposal sites, now and in the future, it is necessary to demonstrate positive schemes for maintaining a vegetative cover. In support of this, a number of revegetative studies are provided.

1. Experimental Greenhouse Studies

a. Objectives - These studies are designed to provide data on the reclamation protential of Lurgi processed shale. Greenhouse studies are beneficial in that they provide preliminary data in a timely manner, can be conducted with a relatively small volume of Lurgi processed shale which is presently available, provide a controlled environment within which leaching and potential uptake studies can be conducted, and provide input to the design of more extensive field demonstration plots.

b. Methods - The experimental greenhouse studies are being conducted by Native Plants, Inc. of Salt Lake City, Utah, and include growth, trace elements uptake, and germination potential studies on, and over, Lurgi processed shale. These studies are scheduled to include a six-month period of growth and began during September 1980. A longer growth period is limited in part by the small size of the treatment pots, as necessitated by the volume of processed shale available for these studies.

The five plant species being tested in these studies include pubescent wheatgrass, Indian ricegrass, Lewis flax, four-winged saltbush and rabbitbrush. These species will be grown as tubelings and transplanted into treatment plots so as to ensure pre-experimental uniform plant size and to minimize the growth period required. The six-month growth period is expected to provide sufficient time for vertical movement of soluble components of the processed shale into the rooting zone. In the processed shale control, as well as the treatment where 15 cm of topsoil covers the shale, roots are expected to come into direct contact with the shale. Growth and trace element uptake experiments are utilizing 25 plots per treatment, which represents five replicates for each species being considered.

Treatment combinations being considered for growth and trace elements uptake studies include 15 cm of processed shale covered by the following combinations of subsoil/overburden, topsoil and pea-size gravel:

- 15 cm topsoil
- 15 cm subsoil/overburden, 15 cm topsoil
- 30 cm subsoil/overburden, 15 cm topsoil
- 30 cm topsoil
- 15 cm subsoil/overburden, 30 cm topsoil
- 30 cm subsoil/overburden, 30 cm topsoil
- 15 cm pea-sized gravel, 15 cm topsoil
- 30 cm pea-sized gravel, 15 cm topsoil

The latter two of the above treatment combinations are being studied to determine if, or how well, the subsoil/overburden material (in the other treatment combinations) is functioning as a capillary barrier to the upward movement of dissolved substances from the processed shale.

Controls being used in the growth and trace elements uptake studies consist of 15 cm of processed shale, 15 cm of topsoil and 30 cm of topsoil. Topsoil and subsoil/overburden being used in the studies are from Tract C-a. The pea-sized gravel is from a totally unrelated site.

Monitoring is being conducted throughout the study to ensure that watering and lighting conditions are uniform for all treatment combinations. At four periods during the study, plants are being evaluated for vigor and growth. Data gathered during these periods includes plant height, leaf number, color and size. Photographic documentation of growth is also being compiled throughout the duration of the study.

After six months of growth, the root systems of the plants will be excavated to view and obtain data on the interaction of the roots with the processed shale. Five individuals of each species in each pot will then be pooled and ashed, and chemical analyses performed. Plant material will be analyzed for boron, molybdenum, fluoride, arsenic and selenium.

Studies of the germination potential of processed shale studies are being conducted using twelve species (50-100 seeds per species), and include five replications for three seeding depths and one control. Seeds are being sown on the surface of the processed shale, as well as at 1 and 2.5 cm depths.

The control treatment consists of topsoil from Tract C-a with seeds sown at a 1 cm depth.

2. Field Demonstration Studies - A number of revegetation plots will be developed on the processed shale disposal area (Figure 5-4-4).

a. High TDS Moisturized Processed Shale (Area 1) - This vegetation plot becomes available early in the life of the facility to allow the maximum possible growing time. This kind of processed shale is the most likely for a commercial operation. The central vegetation plot will be likely over this type of material.

b. Ground Water Moisturized Processed Sale (Area 2) - This revegetation plot becomes available a little later than that in Area 1, and will be used to duplicate the plot on the high moisturized processed shale.

c. Slurry Transported Processed Shale (Area 5) - This plot is designed to address the question of the revegetation over slurry processed shale.

The surface treatment of the processed shale is important to the revegetation study. Parameters which may be varied during the test period include:

- Thickness of capillary break
- Thickness and type of topsoil and/or topsoil-like material
- Plant type
- Fertilizer type and amount
- Irrigation practices (if any)
- Mulch treatments

Specific treatment combinations will be developed based on information obtained from existing RBOSC experimental revegetation plots, Colorado State University intensive study plots, and input from the Oil Shale Office and Colorado Mined Land Reclamation personnel.

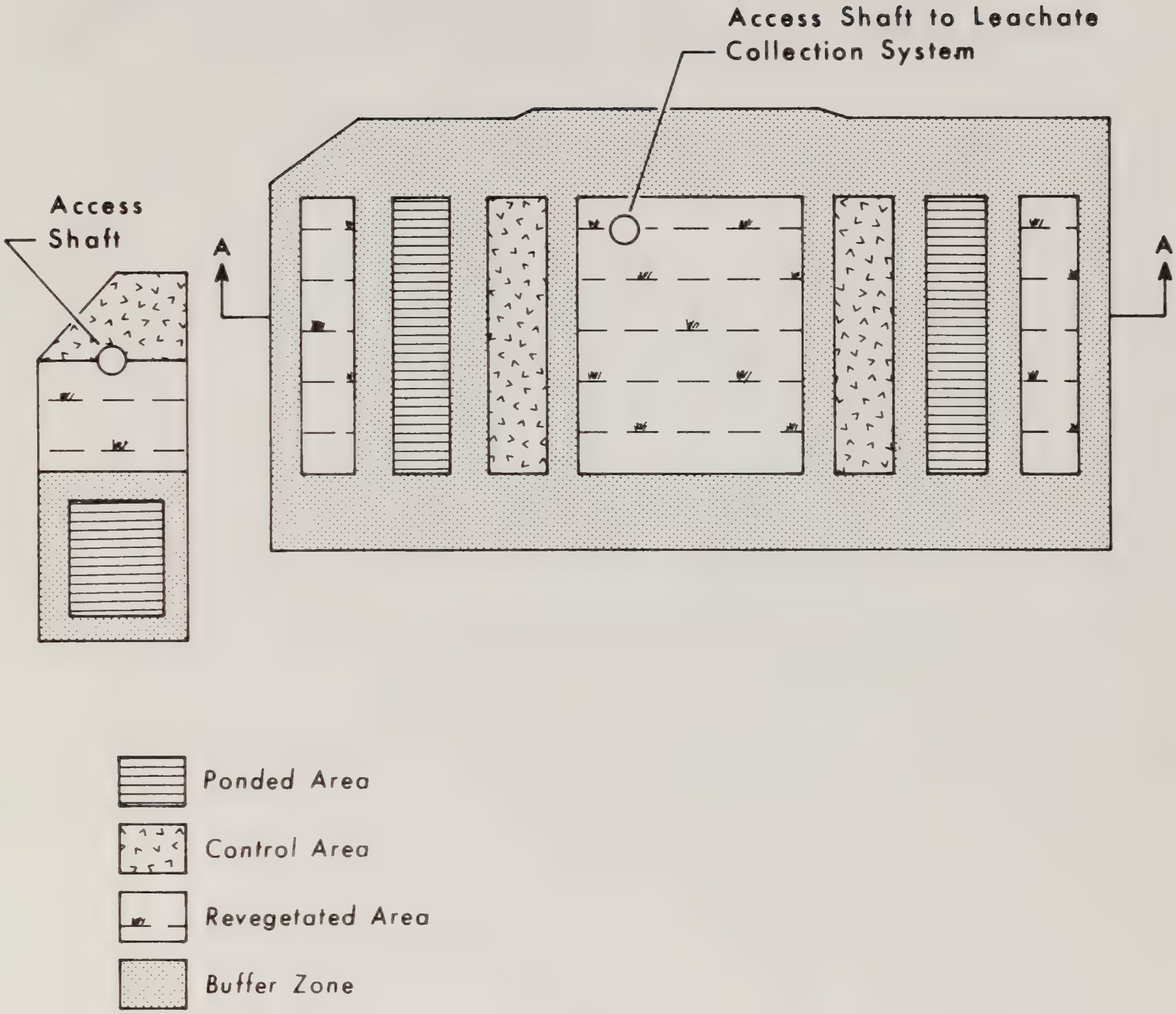



Figure 5-4-4
Layout of Test Area at End of Phase I Disposal

d. <u>Exterior Slopes of the Disposal Pile Dikes</u> - In most instances, revegetation of the exterior of the disposal pile dikes will take place on 3:1 (horizontal:vertical) slopes. Where sufficient space is available, revegetation also will be demonstrated on small areas at 4:1 and 5:1 slopes.

# Section 6

# SUPPORT FACILITIES

# CHAPTER 1
# INTRODUCTION

Support facilities for the Lurgi Demonstration Project will include roads, power supply and distribution line, water supply and distribution system, product oil storage and loading facilities, communications system, building, and explosive storage facility. Each major project activity (mining, processing and processed shale disposal) has its own internal support systems unique to the particular activity. These systems are discussed in the respective section describing the activity, and will not be repeated here.

The locations of most project support facilities are controlled by the locations of the major project features: mine, processing facility, and processed shale disposal area.

Most of the truck traffic carrying equipment, materials, and supplies to Tract C-a will travel from Rifle via State Highway 13, the Piceance Creek road, and County Road 24 (Ryan Gulch road).

Rifle is situated on the mainline of the Denver and Rio Grande Western Railroad (D&RGW) railroad. Goods shipped by rail will most likely be shipped to that area, to be loaded on trucks for final transport to Tract C-a.

Transportation is discussed in Chapter 2.

Power demand will range from 0.9 MW during construction to a maximum of 11 MW during plant operation. This will include power demand from the mine and processing and support facilities. The primary source is the existing 138/240 KV transmission line to Tract C-a which is tied to Moon Lake Electric Association's 138 KV line along the White River about 20 miles north of Tract C-a. A new 138 KV/23 KV main substation will be installed near the existing main substation located in the MIS facility. On-site diesel engine driven generators will be installed to supply the power required prior to completion of the transmission line and delivery substation. These units will be retained as standby emergency power sources. Power supply and distribution are discussed in Chapter 3.

Shale oil will be stored in storage tanks and will be transferred in trucks for transportation to a market (not yet determined by RBOSC). Product storage and transportation are discussed in Chapter 4.

Telephone service will be provided by Mountain Bell Telephone Company by extending existing facilities from Meeker and the existing MIS facility. Communications are described in Chapter 5.

Storage and distribution of fuel and other service products in the mine and processing and support facilities are described in Chapter 6.

Buildings in the mine service area, processing plant, and support facility area are enumerated and described in Chapter 7.

Explosive storage and handling are described in Chapter 8.

## 2.1 ORIGIN AND DESTINATION OF GOODS AND PEOPLE

The bulky machinery and equipment to be used or installed during construction, plus materials and supplies necessary for construction and operation, will originate outside the northwest Colorado area. Whatever their origin, heavy and/or bulky items will probably be shipped by rail. The nearest railheads are the D&RGW spur line at Craig and the mainline at Rifle. There is currently no rail service to the interior of the Piceance Creek basin and none is planned by RBOSC.

Goods shipped by rail from the west or southwest will most likely pass through the Salt Lake City area, then south and east through Price, Green River, Grand Junction and finally to Rifle. From the south and east, goods can travel by rail through either Pueblo or Denver, then to Glenwood Springs and Rifle.

Goods shipped entirely by truck can reach the corridor serving Tract C-a by a number of different routes as shown in Figure 1-1-1. Trucks originating in Salt Lake City or points west will likely reach the tract via Vernal and Rangely rather than swinging south through Grand Junction and Rifle. Trucks from Denver and other points east or south, which will likely constitute most of the truck traffic serving Tract C-a, will pass through Rifle on their way to the tract. Thus, Rifle will likely be a focal point for truck and rail transportation during construction and operation.

During construction, there will be an increase in traffic to the site, primarily due to delivery of construction and plant equipment. It is estimated that an average of 12-14 truckloads per day is expected. Their routes will depend on the location from where they originate which is not known at this time. This traffic load will drop off toward the later stage of construction of the Lurgi Demonstration Project. However, during the operations phase of the project, traffic load of a comparable magnitude will exist mainly due to transportation of the product oil to the market.

Section I, Part 1.3 discussed RBOSC's socioeconomic programs including the transportation of workers.

## 2.2 INTERNAL ROAD SYSTEM

The Lurgi Demonstration Project's internal road system will consist of a haul road for transporting overburden and ROM oil shale, and various service and access roads serving the mine, processing and support facilities, and processed shale disposal area. Safety and efficiency are the controlling factors in the ultimate design and location of all internal roads.

The only public access to the mining operation will be via an entrance near the northeast corner of Tract C-a. All visitors will be required to register at a guard center before being allowed to enter the mine operation area. The guard center will be located on the access road just before the mine facilities area.

In order to gain a more convenient entry to the RBOSC off-tract property, RBOSC requested and received approval from the OSO in the fall of 1980 to construct a service access road from the tract entrance to the Lurgi processing and support facilities area. This road, shown on Figure 1-1-5 as the "Lurgi Access Road" was constructed in the late fall of 1980 to the Tract C-a boundary and completed in January 1981. It was built to specifications approved by the OSO. The road allowed quicker and safer entrance to the project area for plant and disposal site surveying work, geotechnical work, environmental monitoring, and general project planning work.

The portion of Corral Gulch road from the tract entrance to the open pit mine ("Shop/ Office Access Road" on Figure 1-1-5) will be improved to serve as the access road to the mine facilities and will be about 7,500 feet long.

The public access road will be relocated and be about 3,600 feet long. Both roads will be designed and built to specifications approved by the OSO and in consultation with the BLM.

A maximum vertical gradient of 8% will be used on all internal access and haul roads. Vertical curvature on access roads in the internal road system will be designed for safe stopping at a speed of 30 mph. Horizontal curvature will vary from a radius of 100 feet for service roads to 250 feet for haul and access roads. Roads will be crowned for drainage and safety berms installed where required.

The haul road will be surfaced with crushed rock and compacted. Additional information on the haul road is given in Section 2, Chapter 6.1C. The access road from the tract entrance to the processing area will be paved.

## 2.3 REGULATION OF ACCESS

In compliance with lease stipulations and BLM regulations, existing roads and trails will be left open until they enter an area that presents a potential safety hazard to the public. Suitable access to safe water impoundments and non-operating areas will be provided to encourage safe use of the area by the public. Controls will be established to prevent access by the public to areas such as contaminated water storage ponds, unstable slopes, haul roads, construction areas, etc., where hazards may exist. The type of control used will depend on the degree of potential hazard but could include posting signs, barricading roads, or fencing the area. During construction, flagmen or other warning procedures will be used, as necessary, to protect the public. Fences will be provided as required, to ensure the safety of the public. Access to the processing facility will be controlled by security gates located east of the processing and support facilities where County Road 24 terminates at the tract's entrance. A by-pass road around the MIS area will be provided for public access to the Corral Gulch Road southwest of the MIS area. The security station will be located to give free and unrestricted access to the public lands around the MIS area.

Uncontrolled use by off-road vehicles will be restricted. Existing and potential trails will be posted with restrictive warning signs. When necessary, fences, mounds, or trenches will be installed to prohibit use. Where public access is affected, areas will be closed to off-road vehicles only with approval of the BLM and DCM/OS. When mining disturbances force any existing roads to be closed, an alternative road will be constructed to BLM standards to ensure continued access to all lands.

Figure 1-1-5 shows the internal road system.

## 3.1 SCOPE

The following outline describes the power supply and distribution system needed to supply electric power to the various facilities of the Lurgi Demonstration Project. They are located basically in two areas:

- The mine facility
- The Lurgi processing and support facilities

The prime intent is to provide a system that will, while under construction as well as when in operation, have the capability of providing the following features:

- To supply a source of reliable power to operate the facilities
- To blend in with the existing surroundings
- To have, a minimum impact on the existing ecology

## 3.2 POWER DEMAND

The power requirement for the Lurgi Demonstration Plant facilities is presently estimated to be as follows:

| | | |
|---|---|---|
| • The mine facility | = | 0.9 MW |
| • The Lurgi processing and support facilities | = | 10 MW |
| Total | = | 10.9 MW - approximately 11.0 MW |

## 3.3 VOLTAGE LEVELS

The following voltage levels are anticipated to attain the project requirements:

| | | |
|---|---|---|
| Utility incoming power (Moon Lake Electric Association) | = | 138 KV, 3 Phase, 60 Hertz |
| Primary Plant Distribution | = | 23 KV, 3 Phase, 60 Hertz |
| Secondary Distribution | = | 4.16 KV, 3 Phase, 60 Hertz |
| (Distribution within operating areas) | = | 480 V, 3 Phase, 60 Hertz |
| | | 277 V, 3 Phase, 60 Hertz |
| | | 240 V, 1 Phase, 60 Hertz |
| | | 120 V, 1 Phase, 60 Hertz |

## 3.4 DISTRIBUTION SOURCES

A new 138 KV/23 KV main substation will be installed near the existing main substation located in the MIS facility. This substation will consist of the following equipment.

- Primary circuit protectors
- Two 10 MVA transformers
- Secondary selective indoor switchgear consisting of two main secondary circuit breakers, one tie circuit breaker, and two primary plant distribution circuit breakers.
- Associated ancillary equipment, such as control batteries, alarm annunciators etc.

It is intended that the primary circuit protectors be fed from a tap off the 138 KV overhead utility line, and the two primary plant distribution circuit breakers be used to supply power to the various unit substations located at the mine and Lurgi processing and support facilities.

The primary plant distributions system between the new main substation and the unit substations will consist of a fully insulated and shielded overhead cable system, consisting of wooden poles and associated hardware. This cable system will run north from the main substation to the mine facility then northeast along the haul road to the Lurgi processing and support facilities. At each unit substation, the cable system will be tapped or terminated at their transformer primary disconnect switches. The cabling will be attached to each pole approximately 42 feet or higher from the existing finished grade.

In addition to the new power distribution system, relocation of the existing power line to by-pass the East Gulch fill area will be necessary. This will be done during Phase II of the Lurgi Demonstration Project as shown in Figure 1-1-5.

## 3.5 POWER DISTRIBUTION AT THE LURGI PROCESSING AND SUPPORT FACILITIES

The Lurgi processing and support facilities will be provided with two unit substations with indoor switchgear, one 23 KV/4.16 KV and one 23 KV/480 V, arranged for secondary selective operation. The 4.16 KV unit substation will provide the power requirements for the large 4000-volt motors, and the 480-volt substations will provide for the power required by the remaining users via motor control centers located in the unit substation building, process units, or other facility buildings.

Secondary distribution between the unit substations and motors or motor control centers will be by cables laid in aboveground cable trays located on pipeway supports. Secondary distribution between the motor control centers and the motors will be tray laid cable or conduit and wire.

## 3.6 POWER REQUIREMENT AND DISTRIBUTION AT MINE SITE

All proposed mining equipment will be diesel-powered, thus eliminating the need for a complex power distribution network. The only requirements for electrical power at the pit would be power for pit lighting and dewatering. It is estimated that a 625 KVA power line to the pit area will satisfy requirements. For the mine facilities, a 375 KVA power line will be required. Power for the pit and mine facilities will be tapped from the proposed main power line that runs from the existing MIS mine site to the proposed Lurgi process facility.

### 3.7 STAND-BY POWER

During the early phase of construction it is planned to use diesel-engine-driven generators to supply construction power. It is intended that these generators be utilized as part of the permanent plant system after construction, for providing stand-by power in the event of the loss of primary plant or utility line loss. If this is not feasible new stand-by generators will be provided. Also, the overall distribution system will be designed for secondary selection of feeders at both the main substation as well as the unit substations. In the event of the loss of a transformer or one of the primary plant distribution lines, the entire load can be supplied from the remaining transformer and/or line.

## 4.1 PRODUCT OIL STORAGE

The product oil from the Lurgi Demonstration Project will be stored in two product storage tanks. Each tank will have a capacity of 45,000 barrels. The tanks will be of floating roof type.

The tanks and associated accessories will be designed and constructed in strict compliance with all Federal, State, and local regulations and industry codes. The following is a listing of the most important codes and regulations:

- Tract C-a Oil Shale Lease
- OSHA - Title 20 CFR Part 1910
- ANSI Codes B16.5, B96.1
- API Standard 650, 2000
- NFPA Flammable and Combustible Code-30
- NACE RP-01

The tanks will be painted for protection from corrosion and heated to protect contents from freezing during winter. The tanks will be enclosed in a dike for containment of the product oil in the unlikely event of tank failure. The dike will be constructed of impermeable material. The diked area will be:

- One hundred and ten percent of the largest tank plus displacement of all other tanks in the compound below the dike height or liquid level; plus
- A volume sufficient for maximum trapped precipitation (8") and run-off which might be impounded at the time of a spill. The earthen dike will have a flat surface three foot wide on top of the dike.

## 4.2 PRODUCT OIL TRANSFER AND LOADING

A pumping station will be provided near the product oil storage tanks.

Product oil will be transferred from the product storage tanks by heat-traced pipeline to the product oil loading station off the access road to the Lurgi demonstration plant. This site was picked because of suitable topography. Locations within the processing area were considered unsuitable because of the congestion. In addition, a safety problem would exist if there was heavy tank truck traffic on the Lurgi Access Road which is winding and sloped in most parts.

Electric motor driven centrifugal pumps and equipment for tank truck loading will be installed at the loading station.

Relief valves and high-pressure shutdown devices will be installed, as needed, on the pipeline and at the pumping station and loading station facilities.

The pumping station and loading station facilities will comply with the applicable API and NFPA standards. The facilities will also be designed with provisions for containment of product oil in the event of equipment failure or breakage.

## 4.3 PRODUCT OIL TRANSPORTATION

Product oil will be transported by trucks to future-designated places for refining. It is anticipated that an average of 10,000 barrels of product oil per week will be transported. This will require 84 truck loads per week at 5,000 gallons capacity per truck for transportation.

## 5.1 TELEPHONE

Mountain Bell Telephone Company will provide telephone service to Tract C-a from Meeker. Enough circuits will be provided to accomodate intraproject, local and long-distance calls. Switching arrangements will provide interface with the mining facilities, and the processing and support facilities, as well as with the existing MIS facilities.

Temporary radio-telephone facilities will be provided to handle communications during early phases of construction.

Section 2, Chapter 6, Part 6.1 C describes the communication service to be installed in the mining area.

## 5.2 RADIO COMMUNICATION

A temporary radio communications system will be operated by RBOSC. The individual construction and operations contractors will provide and operate their own two-way radio system for on-site communications.

The two-way FM radio system will provide internal project communications where telephone communication is not possible. This system will be used for:

- ROM oil shale and overburden haul
- Raw shale reclamation from stockpile
- Crushed feed oil shale reclamation from storage pile
- Processed shale disposal operation
- Dispatching operational and maintenance people
- Supervision over general facility operations

This chapter describes the plan to supply natural gas, diesel fuel and other service products required to operate mobile equipment during construction and operation of the project. Also described are the storage, distribution and waste disposal facilities necessary for supplying diesel fuel and service products including gasoline, lubricating oil, hydraulic fluid and antifreeze.

## 6.1 SUPPLY, STORAGE AND DISTRIBUTION

Natural gas will be supplied by a distribution system tied in with the natural gas supply to the MIS area. Routing of the existing natural gas supply system is shown on Figures 1-1-3 and 1-1-5.

The estimated amounts of diesel fuel and other service products needed for the operation of mobile equipment are summarized in Table 6-6-1.

TABLE 6-6-1
AVERAGE ANNUAL REQUIREMENTS FOR FUEL AND OTHER SERVICE PRODUCTS
(In Gallons)

| Product | Mine Service Area | Processing and Support Facilities |
|---|---|---|
| Diesel Fuel | 441,000 | 120,000 |
| Gasoline | 37,000 | 70,000 |
| Motor Oil | 2,700 | 500 |
| Other Lube Oils | 500 | 200 |
| Hydraulic Fluid | 800 | 600 |
| Antifreeze | 1,000 | 200 |

Diesel fuel, gasoline, lubricating oil, hydraulic fluid and antifreeze will probably be shipped by rail from their respective points of origin to a siding near Rifle and then hauled by truck to Tract C-a.

During the initial construction period, diesel fuel and gasoline will be stored in skid-mounted tanks at the site.

Motor oil and other fluids will be stored in the durable containers in which they are shipped from suppliers. Permanent tanks for diesel fuel and gasoline for plant operation will be buried and protected to prevent corrosion. Tank storage capacities are shown in Table 6-6-2.

Table 6-6-2

STORAGE CAPACITY

(In Gallons)

| Product | Mine Service Area | Processing and Support Facilities Area |
|---|---|---|
| Diesel Fuel | 60,000 | 30,000 * |
| Gasoline | 10,000 | 6,000 |
| Motor Oil | 1,000 | 500 |
| Other Lube Oils | 300 | 200 |
| Hydraulic Fluid | 1,000 | 500 |
| Antifreeze | 500 | 200 |

*Includes 4,000 gallons at the emergency generator station and 2,000 gallons at the firewater pump station.

The 85-ton end-dump trucks used in the mining area will be serviced between shifts at the mine maintenance facility. Equipment that cannot easily reach this facility will be serviced by mechanics and lube trucks between shifts.

A diesel fuel service station and a gasoline service station will be provided to supply diesel fuel and gasoline. Service station facilities will be installed complete with pumps, valves and piping and will comply with the applicable National Fire Protection Association Standards.

Tanks will be enclosed by dikes to form spill-containment basins as described in Section 7, Chapter 7. Buried diesel and gasoline storage tanks will be installed in areas closest to its major users.

Flammable fluids, other than diesel and gasoline, and service products will be stored in permanent pre-engineered metal buildings designed specifically for storage of these materials. Storage and handling of fuel and other flammable liquids will be in accordance with all applicable regulations including the following:

- Tract C-a Oil Shale Lease
- Design Standards of the American Petroleum Institute, Division of Refining
- Fire Protection Handbook, National Fire Protection Association, Thirteenth Edition
- National Fire Codes, National Fire Protection Association, 1980 Edition
- Colorado Mining Laws, Bulletin 20, Colorado Bureau of Mines
- 30 CFR, Part 55,
- 29 CFR, Part 1926, Sub-part F - Construction Safety and Health Regulations, Occupational Safety and Health Administration, U.S. Department of Labor
- Safety and Health Rules and Regulations, Colorado Occupational Safety and Health Administration
- 43 CFR, Part 23
- 30 CFR, Part 231

## 6.2 DISPOSAL OF WASTES

Waste motor oil, used antifreeze, sludge accumulating in diesel tanks, waste hydraulic fluid and other waste oils will be collected and disposed by local contractor as described in Section 7, Chapter 7. Solid waste disposal is described in Section 7, Chapter 9. Sewage disposal is described in Section 7, Chapter 6.

## 7.1 MINE SERVICE AREA

Major buildings at the mine facilities area will consist of a 12,000 square foot shop/warehouse building, two 12 x 60 office trailers, and two 12 x 60 change house trailers. The shop/warehouse will be a pre-engineered metal building capable of servicing 85 ton end-dump trucks, crawler tractors, motor graders, and miscellaneous support equipment.

## 7.2 PROCESSING PLANT AND SUPPORT FACILITY AREA

The buildings planned for the processing plant and support facility area are listed below:

- Administration/warehouse/maintenance shop building
- Shale crusher structure
- Shale storage building
- Control building
- Utility building
- Firewater pump house
- Electrical substation
- Gate guard house
- Waste treatment building

Some of the major building locations are shown on Figure 4-2-2.

## 7.3 MAJOR BUILDING DESCRIPTIONS

A. Mine Service - Buildings for the mine service area are described in Section 2, Chapter 6.1 C.

B. Processing Plant and Support Facility - The buildings will be provided with heat, lighting, communications, potable water and sanitary facilities as appropriate.

A brief description of the major buildings is given in the following paragraphs:

1. <u>Administration/Warehouse/Maintenance and Shop Building</u> - The administration/warehouse/maintenance shop building will be a one-level building. The building will be constructed of steel structure, pre-fabricated concrete walls, and insulated metal roofing. It will accommodate approximately 30 administrative, engineering, maintenance and medical personnel. The building will provide the following functions:

- Office space for administrators, engineers and office personnel
- Areas for conference rooms
- Storage room for supplies and records
- Locker, change and shower areas
- Sanitary facilities
- Machine shop
- Pipe fabrication shop
- Electrical/instrument shop
- General maintenance shop
- Lunch room with kitchenette unit
- Equipment and parts storage room
- First aid room
- Fire fighting equipment garage
- Ambulance garage
- Mechanical equipment

2. <u>Oil Shale Crusher Structure</u> - The oil shale crusher structure will be a two-level building. It will be a totally enclosed structure which will house the following equipment for oil shale preparation:

- Feed hoppers
- Primary crusher
- Secondary crusher
- Conveyors
- Vibrating feeders

- Vibrating screens
- Bag filter dust collector

This building will be located adjacent to the oil shale storage building.

3. Oil Shale Storage Building - The oil shale storage building will be a one-level structure. It will be rectangular in shape and constructed of pre-fabricated steel and concrete walls. The building will house the following:

- Crushed overburden pile
- Crushed oil shale pile
- Crushed oil shale reclaimer
- Sanitary facilities
- Office space for engineers and operators

The building will be equipped with vents and dust control equipment. This building will be located adjacent to the processing plant area.

4. Control Building - The control building will be a one-level building. It will house the following equipment and facilities:

- Controls and instrumentation for the process plant and support facilities
- Office space for engineers and laboratory personnel
- Laboratory
- Locker, shower and change area
- Lunch room
- Sanitary facilities
- Instrument maintenance shop

The building will be located in the plant process area.

5. Utility Building - The utility building will be contructed of structured steel with metal siding and roofing. The building will house the water treatment equipment.

6. Firewater Pump House - The firewater pump house will be located adjacent to the firewater tanks. The facility will house the firewater pumps and associated motors.

7. Electrical Substation - The electrical substation will be a one-level building to be constructed of pre-fabricated steel. The facility will house the electric switchgears. It will be located adjacent to the existing MIS substation.

8. Gate Guard House - The gate guard house will be a one-level prefabricated steel structure. It will be located at the south side of the processing area.

9. Waste Treatment Building - The waste treatment building will be a one-level pre-fabricated steel structure. It will house chemical feed system, tertiary sand filters, activated carbon system, and control panels. Part of the chemicals used for waste treatment systems will also be stored in this building.

## EXPLOSIVE STORAGE AND HANDLING

The Alcohol, Tobacco and Firearms Division of the U.S. Treasury Department has jurisdiction to enforce Federal regulations pertaining to commerce in explosives, which also include the storage and handling of explosives. Generally, State and Federal mining laws regulate the storage and handling of explosives as well as their use. However, these regulations are compatible with and do not supersede the Treasury Department regulations.

The storage and handling of explosives will be effectively regulated by the Colorado Bureau of Mines and the Mine Safety and Health Administration. It is necessary however, to comply with the laws and regulations as enforced by the Treasury Department and defined in 26 CFR, Part 181. Salient features of these regulations are discussed below.

1. Definition of Explosives - Each year the Treasury Department publishes a list of recognized explosives that are regulated by law. Unmixed ammonium nitrate is not classified as an explosive. The mixed form however, of ANFO (ammonium nitrate-fuel oil), which is sensitive to a number 6 blasting cap, is classified as a blasting agent.

2. Classes of Explosives - Explosives are classified as: 1) high explosives; 2) low explosives; or 3) blasting agents. High explosives (dynamite, for example) can be detonated by a blasting cap when unconfined. Low explosives (black powder, for example) can be caused to deflagrate when confined. Blasting agents include less sensitive explosives, such as ANFO.

3. Storage Facilities for Explosives - There are five type of storage facilities for explosives:

Type 1 - permanent storage for high explosives
Type 2 - portable indoor/outdoor storage facilities for high explosives
Type 3 - portable outdoor facilities for temporary storage of high explosives

Type 4 - facilities for storage of low explosives or blasting agents
Type 5 - facilities for storage of blasting agents

Strict construction codes and limitations apply to each of the five types of storage facilities for explosives. These codes and limitations are detailed in 26 CFR, Part 181, Subpart J. All storage facilities for the project will meet or exceed these codes.

The existing powder magazine at the MIS underground site will be utilized for storage of explosives during the open pit project.

Unmixed ammonium nitrate will be stored in an overhead loadout tank that will not create a fire hazard to other buildings in the mine facilities area. Fuel oil will be stored in a separate, isolated outside tank. Water gel explosives will be stored in approved truck trailers north of the pit safe distances from any anticipated operation, as shown on Figure 1-1-5.

The American Table of Distances, published by the Institute of Makers of Explosives, specifies the distances at which explosives can be safely stored from other structures (public highways, buildings or railways). Also, the tables specify minimum separation distances for blasting agents and high explosives. The amount of explosive to be stored and the design of the storage facility are functions that define the minimum separation distance between multiple storage bunkers, or between storage bunkers and inhabited buildings. The tables will be used in the design of storage and handling facilities for explosives and blasting agents.

4. Transport of Explosives - The guidelines listed below will be followed in transporting explosives and considered, along with pertinent regulations and specifics of the site, in developing detailed safety plans for operations.

- Vehicles containing explosives or detonators will be posted with proper warning signs.
- When vehicles containing explosives or detonators are parked, the brakes will be set, the motive power shut off and the vehicle blocked securely to prevent it from rolling.

- Vehicles containing explosives or detonators will not be taken to a repair garage or shop for any purpose.
- Vehicles used to transport explosives, other than blasting agents, will have substantially constructed bodies and no sparking metal exposed in the cargo space, and they will be equipped with suitable sides and tailgates.
- Explosives or detonators will be transported at times and over routes that expose a minimum number of persons.
- Other materials or supplies will not be placed on or in the cargo space of a conveyance containing explosives, detonating cord or detonators, except for safety fuse and except for properly secured, nonsparking equipment used expressly in the handling of such explosives, detonating cord or detonators.
- Vehicles containing detonators or explosives, other than blasting agents, will not be left unattended, except in blasting areas where loading or charging is in progress.

5. Use of Explosives - People using or handling explosives or detonators will be experienced personnel who understand the hazards involved; trainees will do such work only under supervision of and in the immediate presence of experienced personnel. All blasting operations will be under the direct control of the appropriate supervisor.

Holes to be blasted will be charged as near to blasting time as practical, and such holes will be blasted as soon as possible after charging has been completed. Unused explosives and detonators will be moved to a safe location as soon as charging operations have been completed. Areas in which charged holes are awaiting firing will be guarded, to prevent unauthorized entry. A warning alarm will be sounded to alert personnel in the area before blasting. Faces and muckpiles will be examined for undetonated explosives after each blast, and any undetonated explosives found will be disposed of safely.

Holes will not be drilled where there is danger of intersecting a charged or misfired hole. Workers will not be permitted to return to a misfired hole until at least 15 minutes have elapsed (for electric caps). If safety fuse has been used, 30 minutes must elapse before workers may return.

Smoking will not be permitted within 25 feet of any explosives or detonators. Other detailed rules will be promulgated as required to ensure the safe storage, handling and use of explosives at this project.

Section 7

# ENVIRONMENTAL PROTECTION, HEALTH and SAFETY

Chapter I

## INTRODUCTION

# CHAPTER 1
# INTRODUCTION

Tract C-a lease stipulations require compliance with all applicable Federal, State and local statutes, regulations, and standards relating to water pollution control, water quality, air pollution control, air quality, noise control, and land rehabilitation. Further requirements are to avoid, minimize, and where practicable, repair damage to the environment.

Rio Blanco Oil Shale Company is approaching the development of Tract C-a with a desire to make its activities as free from environmental damage as is practicable. Toward this end, environmental interfaces have been included in all engineering work. This has permitted the development of designs and selection of equipment, alternatives and techniques that will mitigate or eliminate environmental damage.

The health and safety and environmental protection plans presented in this section have a threefold function:

- To set forth the pollution control devices and techniques planned for the project
- To serve as guidelines for detailed design and equipment selection
- To serve as guidelines for construction and operation of the various facilities in a manner to mitigate environmental damage as much as practicable

To cause the least possible impact on water resources, extensive wastewater treatment facilities and water reuse techniques will be employed. In no instance will untreated water be discharged to surface or groundwater sources. Natural drainage will be diverted around operating areas to avoid contamination.

A spill prevention control and countermeasures plan (SPCC) will be instituted for the project.

Rehabilitation, including revegetation, will be a continuing program, commencing in the early years with road and power line corridors. As disposal piles are brought to final configuration, revegetation will progress as closely behind the operation as is practical.

The environmental control plans, equipment and techniques presented throughout the DDP Modification and in this section in particular, are based on current knowledge and technology in the field. Actual construction and operation of this project will provide some additional information on materials and processes which will permit changes and improvements to be made in the environmental control activities. RBOSC intends to take every opportunity to eliminate, minimize or mitigate any environmental degradation that may result from the oil shale development.

# Section 7

# ENVIRONMENTAL PROTECTION, HEALTH and SAFETY

## Chapter 2

## HEALTH and SAFETY

RBOSC management intends to design, construct and operate this project to provide a workplace as free as possible of hazards to either workers or the public. Therefore, the project management and staff will be fully involved in the project safety effort. This chapter covers the Health and Safety aspects of all operations except Mining which is covered in Section 2 Chapter 6, Open Pit Design. References are also given in this chapter to other Sections and Chapters where additional information on health and safety can be found for other subjects.

## 2.1 APPLICABLE REGULATIONS

Pertinent Federal and State health and safety standards and regulations have been reviewed and the project planning has been and will continue to be directed to ensure design compliance. The principal regulations are:

- Code of Federal Regulations (CFR)
  Title 30, Part 55 - Health and Safety Standards for Metal and Non-Metal Open Pit Mining
  Title 29, Part 1926 - Occupational Safety and Health Regulations for Construction
  Title 29, Part 1910 - Occupational Safety and Health Standards
  Title 27, Part 18 - Commerce in Explosives
- Colorado Mining Laws with Safety and Health Rules and Regulations, Bulletin 20, January 1, 1971. Revised April 6, 1976
- State of Colorado, Division of Mines - Safety and Health Construction Standards
- Uniform Building Code
- National Electrical Code
- National Electrical Safety Code
- Various industry standards, such as those of the American Society for Testing and Materials, American Concrete Institute, American Petroleum Institute, American Society of Mechanical Engineers and American National Standards Institute, as appropriate

Prior to the start of construction, a detailed Health and Safety program for the construction phase will be developed to include the necessary rules and codes, to ensure that the facility will be built safely and in full compliance with all applicable regulations. Prior to the start of mining, processing and support facilities operation, a detailed Health and Safety program will be developed in a similar manner to cover all operations.

## 2.2 PERSONNEL RESPONSIBILITIES

The project manager during construction and a member of management during operation will have full responsibility for executing and implementing a program of employee protection and accident prevention. They may delegate authority to expedite and facilitate any application of the program.

A safety professional, responsible to the project manager (construction phase), or manager (operation phase) will be employed on the project. He will be charged with inspections and investigation of work methods for safe performance, orientation of new employees in safety practices, organization of safety meetings and supervision of first-aid treatment and facilities. He will also be responsible for compiling all necessary records, logs and reports pertaining to safety required by the project and by Federal and State governmental agencies. He will investigate and report all accidents involving personnel or equipment and all damage to property caused by fire, flood or other occurrences.

Safety and other supervisory personnel will orient new employees and be responsible for the work methods and safety procedures followed on work assignments performed in their respective areas of responsibility. With the assistance of safety personnel, supervisory personnel will plan for and conduct periodic safety training meetings. They will comply with safety regulatory requirements generally applicable to the work and follow all directives relating to safety instituted by management and the safety engineer consistent with company policy and appropriate regulatory codes.

Subcontractors will be required to comply with the project safety program, standards, procedures, stipulations and regulations.

All employees must learn and comply with all safety rules and regulations applicable to their work and to the general safety of other workers on the project. Management will be responsible to make the project a safe place to work. However, each employee will be responsible for supporting management to provide a safe place to work, to protect himself and his fellow workers against injuries and to report all safety hazards at once to project supervisors.

## 2.3 SAFETY AND ACCIDENT PREVENTION PROGRAM

A management safety committee will be formed with at least one member from each major department. The committee will meet monthly to:

- Promulgate and review safety procedures and policies
- Discuss major accidents pointing out the causes and how the accidents could have been avoided
- Discuss safety hazards and suggest methods to control or eliminate them
- Develop continuing safety programs with emphasis on problem areas
- Review progress of work on any necessary safety improvements

Results of these meetings will be appropriately communicated to all employees through regular supervisory channels.

The safety professional or other delegated person will make routine inspections of work areas. He will immediately bring any inadequate or deficient measure or unsafe work practice to the attention of the appropriate supervisor for correction. The safety professional will inform the appropriate manager of all deficiencies that cannot be corrected immediately or that may result in damage to facilities or equipment or that may create hazardous public exposure. All flammable materials and explosives storage areas, shops, warehouses and other buildings will be inspected at regular intervals.

Appropriate mechanical safety inspections will be part of the equipment preventive maintenance program and as such will be the responsibility of both field and shop mechanical department supervisors and operating department supervisors. Records and reports will be an important part of the preventive maintenance program. Periodic spot check inspections may be made as required.

Management will be responsible for instructing each employee to recognize and avoid unsafe and hazardous conditions connected with his particular job and to be aware of and understand those safety regulations applicable to his working environment. As a minimum, the project's safety and health training program will comply with MSHA Training Regulation and also include:

- Initial indoctrination by the safety supervisor or other representative of management. This indoctrination will cover general information about the safety program and the safety policies and regulations, as well as details relating to site specific Tract C-a safety rules.
- Prework briefing and demonstration by individual supervisors. This phase will familiarize each employee with company approved safe operating and working procedures and with existing or potential job hazards with regard to the specific tasks to be performed by the employee.
- Periodic safety training meetings. These meetings, which will be held by supervisors, will emphasize the safety rules, penalties for violating rules and standard codes, the causes of accidents in a particular trade and ways of preventing accidents. A record of these meetings, including major topics discussed and names of employees in attendance, will be maintained.
- Follow-up field training and supervision to ensure that safety rules and regulations are fully understood and are being complied with. On-the-job safety training is recognized as one of the most effective ways of educating workers.

## 2.4 REPORTS AND LOGS

The management and/or the safety professional will be responsible for establishing and complying with record keeping and reporting requirements. Records and reports will include:

- Personal injuries and treatments received
- Accident investigations
- Reports to compensation carrier
- Requirements of State and Federal agencies
- Disabling (lost-time) and other reportable injuries
- Property damage
- Testing logs, as required for dust, gas or explosives work

## 2.5 SPECIAL CONCERNS

In addition to the information contained in this chapter, other portions of this section also concern health and safety, either directly, as in the case of Chapter 3, Fire Prevention and Control, or indirectly, in other chapters. Sections 2, 3, 4, 5, and 6 also contain information relative to safety design features.

A. Airborne Contaminants - Wherever employees are exposed to concentrations of dust or fumes that are potentially harmful, a monitoring program will determine the levels of exposure and concentrations of the contaminants. Exposure can be alleviated by the proper use of personal protective equipment. Controlled-atmosphere stations will be provided for operators where required.

Maximum allowable concentrations of fumes and dust are shown in Tables 7-2-1 and 7-2-2, respectively.

For the mine, as this will be a surface mine operation, the main contaminant will be fugitive dust. A comprehensive program of haul road watering will significantly reduce this potential problem.

Table 7-2-1

MAXIMUM ALLOWABLE CONCENTRATION OF AIRBORNE CONTAMINANTS*
(Threshold Limit Value - TLV)

| Chemical Compound or Product | Concentration (ppm) |
|---|---|
| Ammonia | 50 |
| Benzene | 25 |
| Carbon dioxide | 5000 |
| Carbon monoxide | 50 (.005% by volume) |
| Chlorine | 1 |
| Gasoline | 500 |
| Hydrogen cyanide | 10 |
| Hydrogen sulfide | 10 |
| Methane | 500 (.05% by volume) |
| Naphtha (petroleum) | 100 |
| Nitrogen oxides | 25 |

*Colorado Mining Laws, Rules and Regulations, Bulletin 20, January 1, 1971, Part 71.2

Table 7-2-2

MAXIMUM ALLOWABLE CONCENTRATIONS OF TOTAL DUST*
(Respirable and Non-respirable)

| Type of Dust | Million Particles Per Cubic Foot |
|---|---|
| Without free silica | 30 |
| With free silica | $300 \div (\% \ SiO_2 + 10)$ |

*Title 30 CFR Part 55.5

B. Noise Control - Because of the remote location of the plant, the community noise criterion is not a major concern. Consequently, the main concern of noise control is the protection of the tract personnel from excessive noise. Refer to Chapter 4 of this section for details on noise control requirements and mitigative procedures.

C. Explosives - The storage, transport, and use of explosives will strictly follow all applicable federal and state regulations. Refer to Section 6, Chapter 8, Explosives Storage and Handling for details.

D. Electrical Facilities - The line distribution system between the main substation and unit substations will be insulated in accordance to industry practice and all applicable codes.

1. Grounding - A grounding system will be provided to ensure a safe operation with respect to electrical hazards. The grounding system will consist of the connection to earth of all equipment requiring grounding. This will be accomplished by the installation of grounding loops or grids, and the interconnection of the equipment required to be grounded to these loops and grids.

2. Lightning Protection - Lightning protection will be provided for all masonry buildings, unless otherwise protected by higher structures, using artificial electrode mounted on their roofs and cable connected to a ground. Tall metal structures will also be connected to a ground system. The pole lines will be protected with a static ground wire atop the poles.

3. Electrical Equipment - All electrical equipment will be of industrial grade suitable for the electrical classification of the area in which this equipment will be installed.

E. Machinery and Equipment - All machinery and equipment will be designed, installed and operated in accordance with all appropriate regulations and safe practice guides to provide a safe working environment. All necessary safety devices and equipment will be provided to guard workers against injury.

F. First Aid and Medical Facilities - Project management will provide for adequate facilities and qualified personnel to ensure prompt and efficient first aid and medical care of injured employees. Personnel qualifications, facilities, services and supplies will conform to the good practice standards of the American Medical Association.

First aid stations will be established to comply with the requirements of the project. The facilities provided will be governed by the number of personnel employed on the project and in consideration of other medical care and facilities readily accessible and available to the work. Adequate identification and directional markers will be provided to denote the location of all project first aid stations.

Two licensed ambulances will be provided for emergency transportation. Each unit will be properly equipped to accommodate a stretcher and allow for prompt, comfortable transportation of personnel to medical or hospital facilities. Fifteen-passenger vans will provide additional emergency transportation, if required. Medical and hospital arrangements will be made with nearby community facilities. All emergency telephone numbers will be posted conspicuously at appropriate locations.

Medical air evacuation by helicopter has been arranged with St. Mary's Hospital in Grand Junction, Colorado. At the present time, RBOSC is a sustaining subscriber to the St. Mary's Hospital (located in Grand Junction, Colorado) "Air Life" helicopter medical evacuation services. A lighted, concrete helipad has been constructed on Tract C-a for the emergency air evacuation service. An emergency room physician is on call at the hospital, where the helicopter is stationed, 24 hours a day, seven days a week.

Primary first aid will be administered by Emergency Medical Technicians (EMT) certified by the Colorado Department of Health. At least one EMT will be on duty at all times. All workers will be given MSHA required first aid training with annual refresher courses.

In the absence of qualified doctors, nurses or first aid attendants, selected supervisory personnel will hold current American Red Cross or U.S. Bureau of Mines first aid certificates. Management will encourage all supervisors to become qualified for MSHA first aid certificates.

First aid kits will conform to MSHA requirements and will consist of a weatherproof container with individually sealed packages for each type of item. First aid kits will be fully equipped before being sent out on each job and checked monthly to ensure that expended items have been replaced.

Standard Stokes type or equivalent stretchers and blankets will be strategically located in the work areas. They will be wrapped in visqueen or other waterproof material and stored in plainly marked and sealed waterproof containers.

G. Health and Sanitation - Drinking water will be secured from sources approved by Federal, State or local health authorities. It will be dispensed by means that will prevent contamination between source and consumer. The use of common drinking vessels will be prohibited. Where single-service cups are used, both a sanitary container for unused cups and a waste receptacle for used cups will be provided. Any container used to distribute drinking water will be clearly marked as to the nature of its contents and will not be used for any other purpose. Outlets for nonpotable water, such as water for industrial or fire fighting purposes will be conspicuously posted, "Danger, Water Unfit for Drinking, Washing or Cooking."

Sanitary facilities will be provided in the number and type that meet Federal, State and local health requirements. These facilities will be maintained and the sewage disposed of in accordance with appropriate sanitary requirements under good public health practice and standards. See Section 7, Chapter 6 for additional information.

Reusable personal protective equipment will be sterilized before being issued to another person. Items requiring sterilization include safety glasses and goggles, and rubber boots or shoes. Hard hat bands, suspensions and winter liners, shells for masks or respirators, and protective earplugs are considered expendable protective items.

All garbage or refuse will be disposed of in designated areas in a manner as stipulated by lease requirements and local or State regulations. See Section 7, Chapter 9 for details.

Required washing facilities will be maintained in a sanitary condition and provided with adequate hot and cold water, soap, individual towels and receptacles for disposal of waste. Emergency showers and eyewash facilities will be provided as required.

H. Signs and Posters - Signs and posters of appropriate design and bearing standard pertinent regulations will be used to convey warnings, directions and instructions to personnel and the public, as required by the lease and other applicable regulations. The observance of such safety and accident-prevention signs will be strictly required of company employees and visitors while on the project.

I. Personal Protective and Life-Saving Equipment - Use of such protective equipment will be complied with as required by regulations and recommended by safety standards. Hard hats, hard-toes shoes, safety belts, goggles, respirators, earplugs and other personal protective equipment will be required where needed. Employees are expected to be responsible for the use and care of this equipment. Life preservers, work vests, ring buoys, nets, safety skiffs or other marine life-saving equipment will be provided for use of personnel working adjacent to or over water.

J. Protection of the Public - Tract areas will be examined for hazards to the public, and suitable controls will be established to prevent access by the public to such hazardous areas as contaminated water storage ponds, unstable slopes, haul roads, construction areas, etc. Suitable access to safe water impoundments and nonoperating areas will be provided to encourage safe use of the area by the public.

Appropriate warning lights for low-flying aircraft will be placed on all structures higher than 200 feet in accordance with FAA requirements.

Portions of the Lurgi Demonstration Project area will be fenced to protect the public from construction and operational hazards. The specific areas will be identified as the project progresses.

K. Toxicology Studies - The potential hazards to human health posed by contact with oil shale ore, raw shale oil, processed shale, and the materials leached out of or extracted from these substances have attracted the attention of both public agencies and industry groups in recent years. A number of programs have been established to investigate these potential hazards. The two toxicology programs which are most pertient to RBOSC are those of the American Petroleum Institute (API) and the Department of Energy (DOE) Oil Shale Task Force. The API program was initiated in 1976, and has been completed. The DOE program is in the inital stages of development.

Both the API and DOE toxicology programs are summarized in Section 9, Chapter 7 of this document. The programs are presented in detail in the RBOSC Environmental Monitoring Scope-of-Work, which is a separate document from this document.

RBSOC has also developed a proposed toxicology program, to address areas not covered by the DOE or API programs, and to investigate RBSOC-specific materials. The RBOSC program is also summarized in Section 9 of this document and presented in detail in the separate scope-of-work document referenced above. The degree to which RBOSC will implement the RBOSC program will be based on examinations of API results and implementation of the DOE program.

L. Industrial Hygiene Program - Results of toxicology and industrial hygiene studies on oil shale-related substances (see Section 9, Chapter 7) will be used to develop an industrial hygiene program and control technologies to mitigate or prevent potential health and environmental hazards. This program will contain procedures to protect workers from undue exposure to harmful material and would addresss such issues as exposure time, appropriate personal hygiene, related medical education, etc.

## Section 7

# ENVIRONMENTAL PROTECTION, HEALTH and SAFETY

## Chapter 3

# FIRE PREVENTION and CONTROL

Fire prevention and control is of particular importance in the project construction, mining and processing activities due to the presence of explosives, flammable liquids and combustible materials in a relatively confined area. The plan outlined in this chapter includes preventive measures, emergency procedures, applicable codes and regulations, and training methods involved in establishing and administering an effective fire prevention and control plan for oil shale mining, and processing operations.

RBOSC management will designate a member of the supervisory staff as the project Fire Marshall coordinator to be responsible for the operation of the fire prevention and control plan.

## 3.1 APPLICABLE REGULATIONS

Recommended practices and standards of the National Fire Protection Association and applicable Federal and Colorado fire protection and prevention regulations will be followed in the development and application of the Lurgi Demonstration Project fire prevention and control programs. A listing of principal applicable regulations follows:

- Tract C-a Oil Shale Lease
- Fire Protection Handbook, National Fire Protection Association, Thirteenth Edition, 60 Batterymarch Street, Boston, MA 02110
- National Fire Codes, National Fire Protection Association, 1980 Edition, 470 Atlantic Avenue, Boston, MA 02210
- Colorado Mining Laws, Bulletin 20, Colorado Bureau of Mines, 1845 Sherman Street, Denver, CO 80203
- Code of Federal Regulations (CFR), Title 30, Part 55
- Bureau of Mines, U.S. Department of the Interior. Title 29, Part 1926, Sub-part F, Construction Safety and Health Regulations, Occupational Safety and Health Administration, U.S. Department of Labor

- Safety and Health Rules and Regulations, Colorado Department of Mines

## 3.2 IDENTIFICATION OF RISKS

In addition to the normal risks associated with construction and operation of a plant with petroleum storage and process facilities, there are some site-specific risks associated with the project.

A. Vegetation at Site and Access Areas - The area required for site development, open pit mining, and access roads is sparsely covered with small trees (Pinyon and Juniper) and mixed brush cover. Therefore, precautions will be required to avoid land fires at all times and especially during dry seasons while construction and site clearing are underway.

B. Off-site Support - Because of the remote location of the plant site, this facility will be self-supporting with respect to fire fighting equipment and personnel to man that equipment during an emergency. There are no nearby communities which could respond during the early stages of a fire and any later help would be necessarily limited by equipment availability, which must be maintained at a minimum level for local protection at any specific location.

C. Site Clearing and Construction - When chain saws are used to remove tree and brush growth, precautions on the use of saws and disposition of cut vegetation are necessary. They are discussed in Part 3.4B of this chapter.

D. Processing Facility Operation - The product of this facility will be a blend of light, middle and heavy oil fractions which will be produced from the Lurgi processing unit. They will be blended before being placed in storage tanks. The product oil will be loaded for shipment into tank trucks from the storage tanks.

## 3.3 MANAGEMENT AND PERSONNEL TRAINING

A. Control Plan Objective - The objective of personnel training in the overall fire prevention and control plan is two-fold:

- To provide instruction in safe procedures for normal operation of the facilities in order to recognize and avoid potentially hazardous situations
- To provide instruction in the specifics of the fire protection plan and the use of fire fighting equipment

B. Supervision and Direction - Line supervisors will be responsible for ensuring that operators perform in the approved safe manner. The plant engineering and technical section, as well as the plant safety group, will assist in ensuring that the supervisors understand and accept this responsibility.

All responsible personnel will receive basic training, as well as on-the-job training, and will be tested to determine the knowledge level attained. Written manuals will be issued to the operators of each process unit covering normal procedures for startup, operation and shutdown; special procedures for emergency shutdown and preparation of equipment for maintenance; and safe practices. The "unit" manuals will also provide detailed information on process equipment controls.

C. Operator Training - Fire fighting training will be given to all personnel at regular intervals to maintain familiarity with fire fighting equipment use and fire fighting procedures. These training sessions will stress knowledge of the fire protection plan, which will detail procedures to be followed and assign duties to be performed by specific persons in case of a fire, major spill or other emergency. The detailed fire protection plan will include plot layouts of processing units which will include location of fire extinguishers, fire hydrants, foam connections and other fire fighting facilities.

In-plant fire teams will be organized among personnel on duty for each shift. A call-out procedure will be used to obtain additional personnel, if required. Members of these fire teams will receive intensive continuous training in actual fire fighting techniques at the fire training area. Operating supervisors, who normally direct a fire attack, will be given special training by the plant fire chief in fire fighting techniques and strategy. This training will be supplemented by formal courses in fire fighting at accredited fire schools.

D. Emergency Procedures - A detailed fire control plan will be developed and implemented when final design is completed. Procedures will include those outlined in the plan, as well as the following:

- Emergency telephone numbers and notification procedures
- Emergency communication procedures
- List and location of fire-fighting equipment
- Fire-alarm procedures and emergency evacuation plans
- Arrangements for emergency first aid

## 3.4 CONSTRUCTION

Fire prevention during construction is of particular concern because of the varied and scattered types of activities and the number of people and equipment items involved. Also, many of the subcontractors and tradespeople working on the project may be unfamiliar with fire prevention procedures and rules.

### A. Fire Fighting Equipment

1. Temporary and Special Equipment - A supply of fire fighting tools and equipment will be furnished at each construction site area. These items will be kept at the respective construction areas at all times during project construction. They will be located to be readily accessible for fire use, and will be reserved and used exclusively on fires and not for construction. Fire boxes will contain enough equipment to adequately supply the men employed by the contractor during any given 8-hour shift. Chain saw crews and dozers working anywhere on the project will be immediately available for ground fire control within or adjacent to the project area.

2. Availibility of Permanent Fire Loop - Fire protection water will be distributed throughout the processing facility by an underground system of fire mains in a grid and loop configuration. Sufficient block valves will be

provided in the mains so that sections of the system can be isolated without undue interruption of the fire protection capability.

The permanent fire loop will be installed as soon as possible during the initial phase of construction. Supply water storage and pumping equipment will also be made available during the construction work.

B. Special Precautions - The following special precautions will be taken:

- Surface Blasting - During the precautionary period (generally May 15 through November 15), working crews or a workman will patrol the surface blasting area looking for fires.
- Welding - Welding will be performed only after flammable materials have been cleared away. Portable fire fighting equipment will be maintained at each welding site during welding operations.
- Spark Arrestors - All diesel and gasoline powered engines, both mobile and stationary, will be equipped with approved serviceable spark arrestors.
- Smoking - During the normal precautionary period (May 15 through November 15 as recommended by the U.S. Forest Service), smoking will be permitted only in safe places, such as along roads, in truck cabs, or in designated areas where all flammable material has been cleared away. Smoking will never be permitted in buildings containing gasoline, diesel fuel, oil or explosives, and "No Smoking" signs will be posted in such buildings.
- Power Saws - Each gasoline power saw will be provided with a muffler in good condition. The clearing and grubbing crew will have fire fighting equipment in the field. Spill-proof metal cans will be used for refueling.
- Storage and Parking Areas - Areas for construction support facilities, equipment service, parking, gas and oil drum storage and explosive storage will be cleared of all flammable materials for a distance of 50 feet. Small stationary engine sites will be cleared of all flammable materials for a distance of 15 feet. Flammable and explosive storage areas will be labeled as such, and "No Smoking" signs will be prominently displayed.

- Oil Filters, Cartridges, and Oily Rags - Used and discarded oil filters, cartridges and oily rags or waste will be collected and taken to an approved solid waste disposal site. Glass jugs or bottles will not be used as gas, oil or waste containers.

C. Open Burning - Open burning is not contemplated as a general practice on the project. Any open burning will require specific application to and approval of the DCM/OS. However, in the event that such burning is required and approved, the following controls will apply:

- No burning will be allowed without advance approval of the fire control coordinator. All oral approvals will be confirmed in writing. Before burning is authorized, weather forecasts will be secured. No burning will be permitted during turbulent weather conditions.
- A burning permit will be obtained from the Colorado Air Pollution Control Division prior to any burning. A copy of the permit will be filed by the project fire control coordinator.
- The coordinator may require burning in one area to be completed and extinguished before burning is started in another area. Based on the National Fire Danger Rating System, if Manning Class III or above is reached, mop-up of unextinguished piles will be immediate and complete with follow-up checks made through the next day to ensure that all fires are "dead out." The project fire control coordinator will determine from appropriate agencies when Manning Class III is reached.

## 3.5 OPEN PIT MINING

Fire prevention and control will be in accordance with the standards set forth in Paragraph 3.1 and any other recognized agencies approved by the Mine Safety and Health Administration.

A. Fuel Storage Facilities

1. Type and Quantity of Fuel Stored - Fuel storage facilities for the mining operation will include two 30,000 gallon diesel tanks and one 10,000 gallon gasoline storage tank.

2. Duration of Storage Period - It is anticipated that the fuel storage facilities will have a life of approximately 58 months.

3. Protection Required - At least one fire extinguisher, rated at not less than 20 B units, will be located outside but within 10 feet of the door of any room used for storage of more than 60 gallons of flammable liquids. At least one fire extinguisher, rated at not less than 20 B units, will be located not less than 25 feet nor more than 75 feet from any outdoor storage area for flammable liquids.

Storage tanks containing flammable liquids will be separated. The storage area will be graded to divert possible spills away from buildings or work areas, and it will be surrounded by dikes, which will form spill-containment basins.

B. Protection of Office, Warehouse, and Shop - Combustible materials, grease, lubricants or flammable liquids will not be allowed to accumulate in areas where they can create a fire hazard. All rubbish and combustible trash will be kept in metal containers. Oily and greasy rags will be kept in covered metal containers. Smoking will be prohibited at or in the vicinity of operations constituting a fire hazard, and "No Smoking or Open Flame" signs will be conspicuously posted. A fire extinguisher, rated at not less than 2 A units, will be provided for each 3,000 square feet of protected building area. At least one fire extinguisher, rated at 2 A units, will be located near the strairway on each floor of multi-storied structures.

Electrical wiring and equipment for light, heat and power sources will be installed in compliance with provisions of the National Electrical Code.

C. Protection of Mobile Equipment - All self-propelled mobile equipment will be provided with suitable fire estinguishers. In addition, some specialized equipment will be provided with special extinguishers, as follows:

- One portable fire extinguisher, having a rating of at least 20 BC units will be provided on all tank trucks or other vehicles used for transporting flammable liquids.
- A fire extinguisher with a 5 BC rating or higher will be placed in a readily accessible location at the operator stations or cabs of cranes, derricks, hoists, etc.
- Self-propelled vehicles used to transport explosives or detonators will be equipped with a fire extinguisher with a rating of not less than 10 ABC units.

D. Run-of-Mine Oil Shale

1. Spontaneous Combustion - Although possibility of spontaneous combustion is highly unlikely, it is possible. The stockpiles will be located at least 50 feet from all buildings and other facilities, and accessways will be maintained around and between stockpiles to permit the approach of fire control equipment.

2. Protection Required - Although fires in stockpiles due to spontaneous combustion is a possibility, the problem will be minor and unusual. Protective measures will be taken such as proper stockpiling methods to prevent excessive air circulation within the pile and maintaining clear accessways for fire fighting equipment. Dozers, loaders, and water trucks will be used to expose and extinguish fires occurring within stockpiles.

3.6 PROCESS FACILITY

A. Facility Description - The details of the facility description are presented in Section 4 of this DDP Modification.

B. Fire Prevention and Control Plan - The fire prevention and control plan for the Lurgi Demonstration Project will incorporate training as discussed in Part 3.3 of this chapter.

The major considerations and guidelines for fire prevention and control in the processing facility are described below.

C. Plant Design, Layout and Protection - Design specifications for all processing equipment and storage facilities will either meet or exceed the requirements of the Tract C-a lease and recognized standards for the oil refining industry. The principal non-governmental agencies that supply codes, standards and other widely accepted industry practices include:

- American Petroleum Institute (API)
- American Institute of Steel Construction (AISC)
- American Society of Mechanical Engineers (ASME)
- American National Standards Institute (ANSI)
- American Concrete Institute (ACI)
- American Society for Testing and Materials (ASTM)
- Hydraulic Institute
- Institute of Electrical and Electronics Engineers (IEEE)
- National Electrical Manufacturers Association (NEMA)
- National Fire Protection Association (NFPA)
- Oil Insurance Association (OIA)

In addition, the design and construction of the plant will conform to the safety requirements of the latest editions of codes and regulations of the Federal, State or local agencies having jurisdiction.

1. Process Units and Auxiliary Facilities - Process vessels, pumps, piping and associated equipment will be designed to withstand temperature and pressure conditions in excess of the normally expected operating conditions. These design conditions allow for temporary excursions from normal conditions and reduce the probability of equipment failure before corrective measures can be taken. Construction materials will be selected specifically for the

process fluids involved, and corrosion allowances will be included to provide extra metal thickness for potential corrosive attack over the life of the process units. To the maximum practical extent, automatic control will be installed that will operate in a fail-safe manner to minimize dependence on the human element. Indicating, recording and controlling devices monitoring pressures, temperatures and flow rates will be integrated with all processing equipment. In addition, alarms and shutdown systems will be used to warn of unusual process conditions and to shut down operation before equipment failure can occur. All of these devices will serve to maintain proper operating conditions and to prevent occurrences that might result in explosions or release of flammable materials from the process units.

Process unit layout is an essential part of controlling and minimizing loss from potential fires. The plant layout follows modern refinery practices and is in accordance with insurance underwriters' recommendations. Some considerations relative to the process unit plot plan are listed below:

- The Administration building, fire station and utility areas will be located so that they will not become involved in a fire or explosion originating in the processing or tankage area.
- Storage tanks will be located so that, in the event of failure, their contents cannot flow by gravity to feed a fire in a process or service area.
- Spacing between process units will be maintained to permit maintenance and hot work to be performed while adjacent units are operating and to minimize mutual involvement of process units in case of fire.
- In locating flares, consideration will be given to wind direction, exposure to adjacent equipment and heat release. Elevated flares will be at least 75 feet above grade and a minimum of 200 feet from operating plants.
- Fire drill equipment and training area will be located downwind of the plant with a minimum clearance of 200 feet from property lines and operating equipment. The area reserved for this purpose will be at least 100 feet square, adjacent to a road and accessible to water supply.

- Access for fire trucks and associated equipment will be provided to all process areas.

Within the battery limits of a single process unit, the following guidelines for equipment location will apply:

- No smoking will be allowed.
- Storage tanks containing flammable material will not be located within battery limits.
- Control houses will be located at the edge of battery limits at least 100 feet from fired heaters.
- Fired heaters will be at least 50 feet from processing equipment handling light hydrocarbons. Individual furnaces will be at least 25 feet apart. Boilers will be located as far from process units as practical.
- Air-cooled exchangers will preferably be located in a clear area with no equipment underneath that might be involved in a fire.

2. Product Storage and Loading Facilities - Facilities for storing large quantities of hydrocarbons will be designed to minimize the possibility of fire and spillage. The layout and construction of storage tanks will follow the requirements of the Tract C-a lease, as well as recommendations and standards set by the NFPA and the API. Fabrication materials for storage tanks will be selected specifically for the fluid to be stored.

Product storage tanks will be situated in a tank farm which will be segregated from the processing areas. Spacing between adjacent tanks and between tanks and process areas will be in accordance with the appropriate NFPA codes or local regulations. In general, the clear distance between tanks will be one-half the greatest dimension of the smaller tank. This clearance will enable fire fighting equipment and personnel to safely approach and control a tank fire. In addition, cooling water streams can be directed at tanks adjacent to one involved in a fire to prevent overheating and structural damage to the adjacent tanks.

All tanks, situated singly or in groups, will be surrounded by dikes which will form spill containment basins. The dikes will be engineered in accordance with requirements of the lease and NFPA standards, as a minimum, and will serve to reduce the possible spread of fire outside the originating dikes area. Interior surfaces of diked areas will be impermeable and each area will be designed for drainage of spills away from tanks into a gathering basin. The dike height will be kept as low as practicable to contain the desired volume of storage. Furthermore, dikes will be located so that fire fighting equipment will have access to any tank with not more than one dike intervening. Also, no smoking will be prohibited in tankage areas.

D. Plant Inspections - Periodic inspections of process equipment and tankage will be made as part of the plant maintenance program. While primarily designed to avoid unscheduled downtime and maintenance, these inspections will also serve to detect and prevent potentially hazardous conditions arising from equipment failure.

E. Fire Protection Equipment - The principal fire fighting agent will be water, foams, and dry chemicals. The fire protection system will be designed so that the agents needed in a particular fire situation will be available in the right places and in quantities sufficient for rapid containment. In setting the size of the fire protection system, the "single-risk concept" will be employed. This concept is based on the assumption that there will be only one major fire in the processing facility at any given time and that the fire will be confined to a single fire risk area. Essentially, the total capabilities of the fire protection system can be employed against that fire.

1. Portable Equipment for Manual Use - Portable extinguishers will be provided for immediate use on fires at their incipiency. Dry-chemical extinguishers will be located in process areas, laboratories, buildings, pumping areas and similar locations where Class "B" fires may occur. Travel distance to a single extinguisher will be not more than 75 feet. One or more two-wheeled, 150-pound, dry-chemical extinguishers will be provided for each fire risk area. Carbon dioxide extinguishers or equivalent equipped with non-conductive discharge horns will be provided for protection of electrical equipment.

Hose carts will be provided to get cooling water on equipment quickly and to supplement hoses carried on fire trucks. One or more hose carts will be located in each fire risk area, depending on the quantity of water that can be applied from monitors and other equipment.

Two-wheeled, pull-type foam carts, which can be easily handled by one man, will be provided at selected locations in the processing facility. These carts will be stocked with a drum of foam concentrate and an inline proportioner to operate from hydrant water. Turret nozzles and hydrants will be strategically located throughout the processing area.

2. Fire Water System - The system and equipment for supplying fire protection water will be designed in accordance with recommendations of the National Board of Fire Underwriters. A tank with a storage capacity capable of supplying the fire protection water requirements continuously for 6 hours will be provided. Pumping capacity will be provided by two or more pumps, rated to maintain minimum hydrant pressure of 150 psig at design flow. For optimum reliability, different types of pump drives will be used. While electric motor-driven pumps are most suitable for remote or automatic starting, at least one pump will be equipped with an internal-combustion engine drive to serve in the event of a power failure.

Fire protection water will be distributed throughout the processing facility by an underground system of fire mains in a grid and loop configuration. Sufficient block valves will be provided in the mains so that sections of the system can be isolated without undue interruption of the fire protection capability. All piping and connections to monitors and hose reels will be protected against freezing.

Hydrants will be located so that any major piece of equipment will be covered by at least two hydrants. In general, a spacing of 150 to 300 feet will be maintained between hydrants. Fixed monitors in processing areas will be spaced 150 feet apart and positioned so as to be accessible during a fire. Hydrants and monitors will be located at least 50 feet from any equipment to be protected. Fixed water spray or deluge systems will be used to protect facilities where application of water by hose or monitors would be difficult or dangerous, as well as isolated or unattended facilities and storage areas where delayed application of water could result in serious fire losses.

3. Other Fixed Systems - Storage tanks will be equipped with piping connections designed for subsurface injection of foam. This technique, the most recent development in foam application for fighting tank fires, is fully endorsed by the NFPA. Portable foam towers will also be provided for pumping foam over the top of tank shells directly onto the oil surface.

4. Large Mobile Fire Fighting Equipment - The large mobile fire fighting equipment that will be available for use in emergencies includes the following:

- One pumper type fire truck having a capacity of 1000 gpm. This truck will also be equipped with a foam system as described below
- One foam-concentrate storage trailer.

Equipment, normally used for operation, which will be available for fire fighting includes:

- Water trucks
- Dozers and graders
- Front-end loaders

5. Special Equipment - The fire truck described above will be equipped to combat oil fires. This truck will be capable of pumping volumes of foam solution for storage tank and spill fire protection. Supplementary quantities of foam concentrate will be stored in a mobile tank trailers for use where needed.

F. Communication and Alarm System - An in-plant system for emergency communication and alarm is essential to alert and call personnel in the event of a fire or other hazardous situation, to inform personnel of actions required, to receive and transmit reports at the scene of an emergency, and to call and coordinate efforts with outside groups that will provide aid. To ensure rapid notification and sounding of the plant fire alarm, a separate telephone number will be assigned for fire reports and a separate telephone, equipped with a loud alarm, will be provided at a constantly manned point to receive emergency calls. The plant siren, coded to designate the general area of emergency, can be actuated from this point. Telephone call lists will be established to summon aid when manpower is limited. Walkie-talkies and two-way radio equipment will be provided in fire vehicles to help coordinate fire fighting efforts. These backup systems are essential in the event the plant telephone system is damaged.

3.7 PROTECTION OF VEHICLES AND MOBILE EQUIPMENT

Trucks, dozers, mobile cranes, hoists etc. will be protected by the installation of fire extinguishers as described in paragraph 3.5.D of this Chapter.

3.8 SHALE HANDLING AND STORAGE

A. Main Storage Pile - The main pile for long term storage of shale will be protected as described in paragraph 3.5.D of this Chapter.

B. Enclosed Live Storage Pile - This pile, which serves as a two-day operating storage and belt conveyor supply source, will be protected by sprinkler systems. These sprinkler systems will be fed directly from the main plant underground protection loop. The sprinkler heads will be mounted above the pile on the underside of the enclosure roof.

C. Crushers, Conveyors, and Baghouses - This equipment, which for the most part is enclosed, will be protected by sprinkler systems or deluge pipes as required. The water supply required to provide this protection will be taken directly from the main underground fire water loop.

3.9 OFFICES, WAREHOUSES, AND SHOPS

Combustible materials, grease, lubricants or flammable liquids will not be allowed to accumulate in areas where they can create a fire hazard. All rubbish and combustible trash will be kept in metal containers. Oily and greasy rags will be kept in covered metal containers.

Smoking will be prohibited at or in the vicinity of operations constituting a fire hazard, and "No Smoking or Open Flame" signs will be conspicuously posted. A fire extinguisher, rated at not less than 2 A units, will be provided for each 3,000 square feet of protected building area. At least one fire extinguisher, rated at 2 A units, will be located near the stairway on each floor of multi-storied structures.

Electrical wiring and equipment for light, heat and power sources will be installed in compliance with provisions of the National Electrical Code.

In addition to the A type extinguisher units noted above, B and C type units will also be provided. The basic use of each is as follows:

- Class "A" - Fires which occur in ordinary combustibles such as wood, paper, cloth, and some plastics. The most commonly used agent for extinguishment is water, which cools and quenches. They can also be extinguished by special dry chemicals that provide a rapid knockdown of flame and form a retardent coating which prevents flashback. Extinguishers suitable for Class "A" fires are identified by a green triangle containing the letter "A".
- Class "B" - Fires which occur in the vapor-air mixture over the surface of flammable liquids such as grease, gasoline, chemicals, etc. A smothering or combustion inhibiting effect is necessary to extinguish Class "B" fires. Dry chemical, carbon dioxide, foam, and water fog can all be used depending on the circumstances. Extinguishers suitable for Class "B" fires are identified by a red square containing the letter "B".
- Class "C" - Fires that occur in electrical equipment which requires non-conducting fire extinguishing agent. Water, except when used with a special nozzle, conducts electricity which can severely injure the firefighter or cause severe damage to the electrical equipment. Dry chemicals can be used but will leave a deposit that is extremely hard to remove. Therefore the most preferred agent to use is carbon dioxide or equivalent. Extinguishers suitable for Class "C" fires will be identified by a blue circle with the letter "C" inside.

## 3.10 STORAGE OF FUEL AND FLAMMABLE MATERIAL

The same protection described for the open pit facilities will be provided for fuel and flammable materials (see Part 3.5 of this Chapter).

## 3.11 MAINTENANCE OPERATIONS

Fire extinguishers, water hoses, and other fire fighting equipment will be located conveniently so that they will be ready for use in case of fire.

Employees doing welding will wear fire resistant guantlet gloves and aprons of asbestos or leather, or equivalent material, as protection against heat and sparks. No employee will leave a torch until the oxygen and acetylene valves have been completely shut off.

Whenever practicable, all arc welding and cutting operations will be shielded by non-combustible or flame-proof screens. When welding or cutting is such that normal fire precautions are not sufficient, additional personnel will be assigned to guard against fire. Welding or cutting will not be performed in atmospheres containing more than 1.0% of flammable gases. Any tank, vessel, or piping system that has contained a toxic or flammable substance will be drained thoroughly cleaned of such substance, ventilated and tested before being welded, cut or heated.

Oxygen cylinders in storage will be separated from fuel-gas cylinders, reserve stocks of carbides, or highly combustible materials by a minimum distance of 20 feet or by a non-combustible barrier at least 5 feet high having a fire-resistance rating of at least 1/2 hour.

## Section 7

# ENVIRONMENTAL PROTECTION, HEALTH and SAFETY

## Chapter 4

# NOISE CONTROL

# CHAPTER 4
# NOISE CONTROL

Noise is an unavoidable result of mine construction and operation. RBOSC facilities will be designed and built in accordance with tract lease terms and applicable regulations, laws, and standards.

## 4.1 REGULATIONS

Federal and State of Colorado legislation pertaining to noise control has been examined. Continued review will ensure compliance during all phases of the project.

The following is the principal noise legislation relating to mine safety and environmental impact.

- Mine Safety and Health Administration (MSHA) regulations Title 30 Code of Federal Regulations, Part 55, "Health and Safety Standards, Open Pit Metal and Nonmetallic Mining."
- Environmental Protection Agency (EPA) regulations Title 40 Code of Federal Regulations, Part 202, "Motor Vehicles Engaged in Interstate Commerce."
- "The Noise Control Act of 1972" as amended by "The Quiet Communities Act of 1978" Public Law 92574.
- Colorado Revised Statutes Title 25, Health Article 12, "Noise Abatement."

## 4.2 NOISE LEVELS

The level of noise generated collectively during constructing and mining activities cannot be accurately predicted. Individual readings from representative operating equipment include:

- Dozer up to 100 dbA*
- Haul truck 96 dbA* (from outside the cab enclosure)

- Highway truck 85 dbA
- Frontend loader 80 dbA (from 50 ft)

*The above individual noise level readings experienced by an operator or surrounding personnel can be reduced by at least 29 dbA with the wearing of protective equipment such as ear plugs or ear mufflers.

## 4.3 CONTROL METHODS

MSHA regulations (30 CFR, Part 55.550) limit the time employees can be exposed to dbA levels on the minesite. The following table specifies these levels:

PERMISSIBLE NOISE EXPOSURES

| Duration Per Day (hours) | Noise Level (dbA) |
|---|---|
| 8 | 90 |
| 6 | 92 |
| 4 | 95 |
| 3 | 97 |
| 2 | 100 |
| 1½ | 102 |
| 1 | 105 |
| ½ | 110 |
| ¼ or less | 115 |

No exposure shall exceed 115 dbA; impact or impulse noise is not to exceed 140 dbA.

If exposures exceed the limits prescribed by MSHA, appropriate control methods will be employed. These controls include:

- Administrative - reducing time of exposure
- Engineering - source or path control

- Personal protective equipment (ear plugs or ear mufflers)
- Conducting truck loading, unloading and hauling operations so that noise is kept to a minimum.

All motor carriers engaged in interstate commerce and under the control of this project will be equipped with adequate mufflers and other equipment required to meet the limits stated in 40 CFR, Part 202.2. Measured from 50 feet of the centerline of travel, noise levels may not exceed:

up to 35 mph . . . . . . . . . . . . . . . . . . . . . . 86 dbA
over 35 mph . . . . . . . . . . . . . . . . . . . . . . 90 dbA

Despite its remote location, the project will abide by Federal and State standards to minimize environmental impact and ensure the public is not subjected to excessive noise levels. General area limits are stated in Colorado Revised Statute 251210B. The levels permitted by this regulation are summarized in the following table:

NOISE LEVEL PERMITTED FROM A PROPERTY LINE
AT A DISTANCE OF 25 FEET OR MORE (dbA)

| Zone | 7:00 AM to Next 7:00 PM | 7:00 PM to Next 7:00 AM |
|---|---|---|
| Residential | 55 | 50 |
| Commercial | 60 | 55 |
| Light Industrial | 70 | 65 |
| Industrial | 80 | 75 |

## 4.4 NOISE MONITORING

Periodic noise level measurements will be taken with sound pressure levels analyzers and recorders (See Section 9, Chapter 3).

## Section 7

# ENVIRONMENTAL PROTECTION, HEALTH and SAFETY

## Chapter 5

# AIR QUALITY CONTROLS

# CHAPTER 5
# AIR QUALITY CONTROL

RBOSC recognizes that preservation of the air quality of the Piceance Basin is of the utmost importance. Thus, every reasonable effort will be made to control fugitive dust, to minimize particulate and gaseous emissions, and to maintain air pollutants at levels below the State and Federal standards. The best available control technology will be used.

## 5.1 ROADS AND CONSTRUCTION AREAS

The primary air pollutant generated by construction and mining operations will be fugitive dust. Proper abatement and preventative measures will be provided to minimize escape of fugitive dust from unpaved roads and other disturbed areas in the project area during initial construction activities. The proposed dust control techniques from the major sources of fugitive dust associated with the project are listed in Table 7-5-1.

A. Roads - Traffic will be confined to specified roads, corridors and designated construction areas to minimize land disturbance. Routing, speed control and closure of construction areas to extraneous traffic will reduce the total dust load in the airshed. The use of off-road vehicles will be restricted. During road construction, the roads and parking areas will be watered frequently with trucks and/or sprinkler systems to allay fugitive dust. The road base will be compacted to 90% in accordance with the Proctor test to stabilize the roadbed and help reduce dust emissions. Loose debris will be graded from the roads to maintain a hard, smooth driving surface. The application of chemicals to the roadbed for stabilization will be used wherever possible and practical.

RBOSC has tested a number of dust suppressant chemicals to control fugitive emissions on roads and disturbed areas at Tract C-a. Most, including Coherex, have not been effective on roads carrying high traffic volume.

TABLE 7-5-1

FUGITIVE DUST EMISSION SOURCES AND CONTROLS

RBOSC LURGI DEMONSTRATION PROJECT

| Emission Source | Control Technique | Percent Control |
|---|---|---|
| Overburden removal | none | 0% |
| Overburden haul | suppressants | 85% |
| Overburden dumping | none | 0% |
| Ore removal | wet ore | 50% |
| Ore haul | suppressants | 85% |
| Ore dumping | wet ore | 50% |
| Water trucks | suppressants | 85% |
| Access road traffic | 90% compaction | 80% |
| Topsoil erosion | rapid revegetation | 75% |
| Overburden erosion | rapid revegetation* | 75% |
| Ore stockpile erosion | none | 0% |
| Drilling | water injection | 90% |
| Blasting | wet hole blasting** | 50% |
| Cement batch plant | bag filter | 99% |
| Disturbed areas erosion | none | 0% |
| Run-of-mine ore load out to primary crusher | none | 0% |
| Primary crushing/screening | baghouse | 99% |
| Secondary crushing/screening | baghouse | 99% |
| Crushed ore conveying to building containing stockpile | baghouse | 99% |
| Crushed ore conveying to feed hopper upstream of Beltavator | baghouse | 99% |
| Crushed ore transfer to Lurgi feedhopper | baghouse | 99% |
| Processed shale transfer to disposal conveyor | baghouse | 99% |
| Processed shale transfer to processed shale disposal area | covered | 99% |
| Processed shale disposal via stacker in processed shale disposal shale | wet processed shale | 90% |
| Processed shale erosion | water and revegetation | 50% |

* Phase I only
** Ore blasting only

Recently, encouraging results have been obtained on high traffic areas using lignon sulfonate, a penetrating chemical derived from the pulp and paper industry. RBOSC will use this dust suppressant in combination with watering, to control fugitive dust from roads and other disturbed areas where appropriate.

B. Construction Areas - Development activities will be coordinated so that lands are disturbed only when necessary and damage to existing vegetation is minimized. Straw, mulch or chemical dust suppressants will be used where appropriate to prevent excessive erosion by wind or water until vegetation can be established.

During construction of the processing facility, access areas will be watered frequently by water trucks to control fugitive dust around work areas. The processing area and access will be paved or covered with gravel as soon as the construction activities will permit. Compaction and the watering will be used as needed, to prevent blowing of soils until paving, revegetation or other permanent cover is in place. The topsoil removed from the mine and other disturbed areas will be stockpiled and revegetated. Revegetation will be completed as soon as practical after the pile is brought to its final configuration. Mulches or chemical dust suppressants can be applied as temporary measures if deemed necessary.

## 5.2 MINING OPERATIONS

A. Drilling - Dust from drilling operations can be effectively controlled by water injection and by using standard cyclone collectors on the rotary drills. Water injection will be controlled manually by the drill operator to maintain dust-free operations.

B. Blasting - Dust from blasting operations will be controlled by employing good blasting practices and designing all blasts to prevent overshooting (see Section 2, Chapter 6). The dust generated by blasting of the ore and deeper portions of the over-burden will also be reduced by the high moisture content of these materials due to their proximity to the Upper Aquifer.

C. Overburden and Oil Shale Removal - Truck-shovel methods will be used for overburden and oil shale removal (see Section 2, Chapter 6). In loading the materials into haul trucks, the fall distance from the bucket to the bed of the truck will be minimized, thus preventing excessive emissions. For oil shale removal operations, it is anticipated that low emissions of dust will result because of the high moisture content of the shale removed from the Mahogany zone and the limited amount of fines generated by the blasting and removal operations.

Overburden material removed from the mine site will be used as fill material for the mine facilities area and the haul road, for constructing the containment dikes of the processed shale disposal area or will be placed in the overburden stockpile adjacent to the open pit.

Overburden used as fill at the mine facilities area will be compacted and watered to control dust emissions. Dust suppressant chemicals and other control measures will be used where appropriate. Areas that will remain undisturbed after construction activities are completed will be topsoiled and revegetated.

The fill areas along the haul road will primarily be large angular rock, and, thus, these slopes should not be a significant source of fugitive emissions. Watering of the overburden materials after it is spread along the road corridor will help control dust from this source.

The overburden material used in constructing the containment dike for the processed shale disposal area will be compacted for stability and watered to control dust. The outslopes of these dikes will be topsoiled and revegetated as soon as construction activities on the dike slopes are completed.

The concrete batch plant is another potential source of particulate emissions. This source will be controlled by using bag filters to remove nearly all of the particulate matter from the emission streams.

## 5.3 RETORT FEED PREPARATION

A description of the retort feed preparation system and dust control equipment is given in Section 3. Estimated particulate emissions and data on emission control devices for the retort feed preparation operation will be discussed herein.

A. Stockpiling of ROM Oil Shale - The mined oil shale will be dumped by end dump trucks onto an oil shale stockpile located adjacent to the Lurgi processing facilities. Enclosure of the oil shale stockpile is not being considered because it is anticipated that the stockpile will not be a significant source of dust due to the low percentage of fine materials. Water application to the stockpile is not being considered as a possible dust control measure because of problems that would occur in the handling and crushing of a wet material.

B. Reclaiming from ROM Oil Shale Stockpile - Oil shale will be reclaimed from the ROM oil shale stockpile by a front-end loader and then dumped to a feed hopper, which is equipped with a grizzly screen to control the size of shale to the crusher.

The control of particulate emission (dust) will be by maintaining minimum fall distance in the reclaiming and dumping operations. In addition, the grizzly screen at the feed hopper will be maintained at negative pressure to control dust emission from the dumping operation.

C. Crushing and Screening - The primary crusher, screen feed hopper, vibrating screens, secondary crusher and all transfer points of conveyors will be maintained at negative pressure by a centralized baghouse filter cleaning system (see Figure 3-1-1).

Beltavators, used to convey the crushed and screened feed shale, trap the conveyed material between two belts in elevated sections, thus minimizing dust emissions. Other transfer conveyors will be fully covered.

D. Crushed Oil Shale Storage - Crushed and screened oil shale will be conveyed to and stored in the crushed oil shale storage building by a belt tripper conveyor. Wind erosion or wind blown dust problems will not occur, because the crushed shale storage pile is totally enclosed in a building. The building ventilation system will be equipped with air filters to prevent particulates emission to the atmosphere.

E. Retort Feed - A rotary plow feeder will be used to remove crushed shale from the storage pile onto a collecting belt. This tunnel type feeder will not cause dust emission in the crushed shale storage building.

The collecting belt conveyor will feed crushed shale to the Lurgi retort feed hopper. The feed hopper as well as the sample cutter, weigh belt feed, and the transfer point of the belt conveyor will be connected to a bag filter type dust collection unit to control fugitive dust.

F. Dust Control Equipment - The proposed dust control equipment for the retort feed preparation and the efficiencies of the control devices for each system are shown in Table 7-5-2. The methods of controlling particulate emissions from the retort feed preparation system meet the requirements for Best Available Control Technology (BACT) as specified by EPA, Region VIII.

## 5.4 PROCESSING AND SUPPORT FACILITIES

A. Processing - A detailed discussion of processing emissions is included in Section 4, Chapter 3. Data on the estimated stack emissions for the Lurgi unit are summarized in Table 7-5-3. Additional data on air quality control for the Lurgi retort and support facilities are discussed below. Because of the nature of Colorado oil shale deposits and the design of the Lurgi retort, the process is essentially a self-contained stackgas scrubber (refer to Figure 4-3-1). Recycled processed shale along with fresh shale which has just been retorted flows from the surge bin into the vertical lift pipe for combustion of the residual carbon. Combustion takes place in the lift pipe after preheated air contacts the coke on the processed shale. This combustion step converts the sulfur in the processed shale to $SO_2$ and also converts some of the naturally occurring carbonates in the oil shale to oxides. The

## TABLE 7-5-2

## RETORT FEED PREPARATION - EMISSION CONTROLS

| | Feed to Primary Crusher | Primary Crusher | Vibrating Screens | Secondary Crushers | Crusher Conveyor | Storage Pile Feed Conveyor | Loading to Storage Pile | Retort Feed Conveyor | Retort Feed to Processing |
|---|---|---|---|---|---|---|---|---|---|
| Material (Shale) Handled (TpH) | 400 | 400 | Two-360 ea. | Two-320 ea. | 720 | 400 | 400 | 185 | 185 |
| Number of Stacks or Discharge Points | No stack | 1[1/] | No stack[1/] | No stack[1/] | No stack | No stack | 1 | No stack | 1 |
| Stack Height and Inside Diameter (ft) | -- | TBD[2/] | -- | -- | -- | -- | TBD[2/] | -- | TBD[2/] |
| Air Flow (Design) (ACFM) | -- | TBD[2/] | -- | -- | -- | -- | TBD[2/] | -- | TBD[2/] |
| Exit Temperature (°F) | -- | Ambient +60 | -- | -- | -- | -- | Ambient +60 | -- | Ambient +60 |
| Control Device | -- | Baghouse[1/] | -- -- | -- -- | Fully closed conveyor | Fully closed conveyor | Baghouse | Fully closed conveyor | Baghouse |
| Control Device Efficiency (%) | -- | 99.8 | -- | -- | No emission | No emission | 99.8 | No emission | 99.8 |

Notes: 1/ A centralized baghouse (filter) cleaning system will be provided for the crushing and screening operations, including the transfer points of the crusher conveyor and the crushed shale storage pile feed conveyor.

2/ TBD - to be determined. The design air flow, the height and diameter of the stacks will depend on detailed design of the equipment involved and vendor selection. They will be provided later as detailed engineering design proceeds.

TABLE 7-5-3

LURGI DEMONSTRATION RETORT FLUE STACK EMISSIONS

| | |
|---|---|
| Number of Stacks | 1 |
| Stack Location | Lurgi Structure |
| Stack Height, Ft. | 300 |
| Stack Diameter, Ft. | 8 (Est.) |
| Stack Gas Properties | |
| Gas Flow | |
| Lb/Hr | 266,484 |
| CFM | 61,000 |
| $SO_2$ Content | |
| Lb/Hr | 18 |
| PPM | 30 |
| $NO_x$ Content | |
| Lb/Hr | 127 |
| PPM | 300 |
| Particulate | |
| Lb/Hr | 41 |
| Grains/ACF | 0.346 |
| Hydrocarbons | |
| Lb/Hr | 232* |

* Methane

oxides then react with the $SO_2$ in the presence of excess oxygen to form sulfates. The following equation is an example of this oxidation process:

Carbonate decomposition: $CaCO_3 \rightarrow CaO + CO_2$

$SO_2$ Reaction: $CaO + SO_2 + \frac{1}{2}O_2 \rightarrow CaSO_4$

The conditions in the lift pipe are such that at least 93% of the available sulfur from combustion is converted into the sulfate form with the balance passing out in the flue gas stream in a concentration of less than 30 ppm as $SO_2$. Any sulfur in auxiliary fuel (shale oil liquids, shale oil product gas or natural gas) is likewise converted to the sulfate in the lift pipe.

The efficient removal of sulfur is the result of the large excess of oxides compared to stoichiometric requirements to oxidize the $SO_2$ to sulfates. A sulfur balance comparing the sources of sulfur in the feed shale to that in the retorting products and by-products is shown in Table 4-3-7.

Because the lift pipe will run at relatively low temperatures the $NO_x$ content of the flue gas generated in the lift pipe will be less than 300 ppm. The $NO_x$ is generated almost exclusively from organic nitrogen compounds present in the coke burned in the lift pipe; essentially none is the result of atmospheric nitrogen. The $NO_x$ concentration is not expected to increase even though operating temperatures in the lift pipe may deviate somewhat from the design temperature of 1240°F since significant quantities of $NO_x$ are not formed from atmospheric nitrogen at these temperatures. A comparison of the organic nitrogen in the feed shale and in the retorting products is shown in Table 4-3-8.

Carbon monoxide, CO, will also result from the combustion process in the lift pipe. The concentration of CO is expected to be less than 90 ppm, however, since the lift pipe runs at a temperature that is sufficiently high to assure low CO concentrations, and the flue gas fuel contains about 5% oxygen.

As described in Section 4, Chapter 3, a substantial portion of the particulates (processed shale) is dropped out of the flue gas in the collecting bin and is circulated back to the retort to supply the necessary process heat. The flue gas and the remaining portion of the processed shale is carried from the collecting bin to the heat recovery system for preheating air and generating steam. After the flue gas has been cooled to about 570°F, it passes through a cyclone that is designed to remove approximately 56% of the remaining dust present in the flue gas.

Flue gas leaving the cyclones passes into a conditioner where water vapor from the cooling conveyor (which is used to cool processed shale to the discharge temperature) increases the humidity of the flue gas. This humidified gas passes into the electrostatic precipitator where more than 99.9% of the remaining solids are removed. The dedusted flue gas from the electrostatic precipitator then flows up the stack.

Overall recovery of the dust from the flue gas is approximately 99.98% (Table 7-5-4). As the flue gas passes through the dust removal equipment the dust concentration is reduced from 1.07 pounds of solids per pound of flue gas to approximately $1.5\times10^{-4}$ lb of dust per pound of flue gas (150 ppm). The total particulate discharged in the flue gas is only 41 pounds per hour (Table 7-5-4).

The use of bag filters, which, in many cases, is as effective as electrostatic precipitators in removing particulates, cannot be considered for the demonstration unit because the flue gas temperature is designed for 460°F. This high exit temperature greatly limits the selection of fabrics available for bag filters.

Figure 7-5-1 is a process flow diagram showing the principal components of the Heat Recovery and Flue Gas Dedusting System of the Lurgi retort. The concentration of $SO_2$, $NO_x$ and particulates in lb/hr are shown at each point in the treatment process.

During the test runs made on this demonstration unit, RBOSC will attempt to optimize the conditions within the lift pipe to minimize the overall discharge of $SO_2$, $NO_x$ and CO consistent with good oil recovery from the retort. The operation of the incinerator and the scrubber on the distillation gas

TABLE 7-5-4

LURGI RETORT FLUE GAS

ESTIMATED PARTICULATES EMISSION

| | | L-R Flue Gas |
|---|---|---|
| Number of Stacks | | 1 |
| Stack Height | (ft) | 300 |
| Stack Diameter | (ft) | 8 |
| Flue Gas Flow | (PPH) | 266,500 |
| Exit Temperature | (°F) | 460 |
| Control Devices | | Cyclone and electrostatic precipitator in series |
| Control Device Efficiencies: | | |
| - Cyclone | (%) | 56 |
| - Electrostatic Precipitator | (%) | 99.92 |
| - Overall | (%) | 99.98 |
| Estimated Emission with Control | (ppH) | 41 |

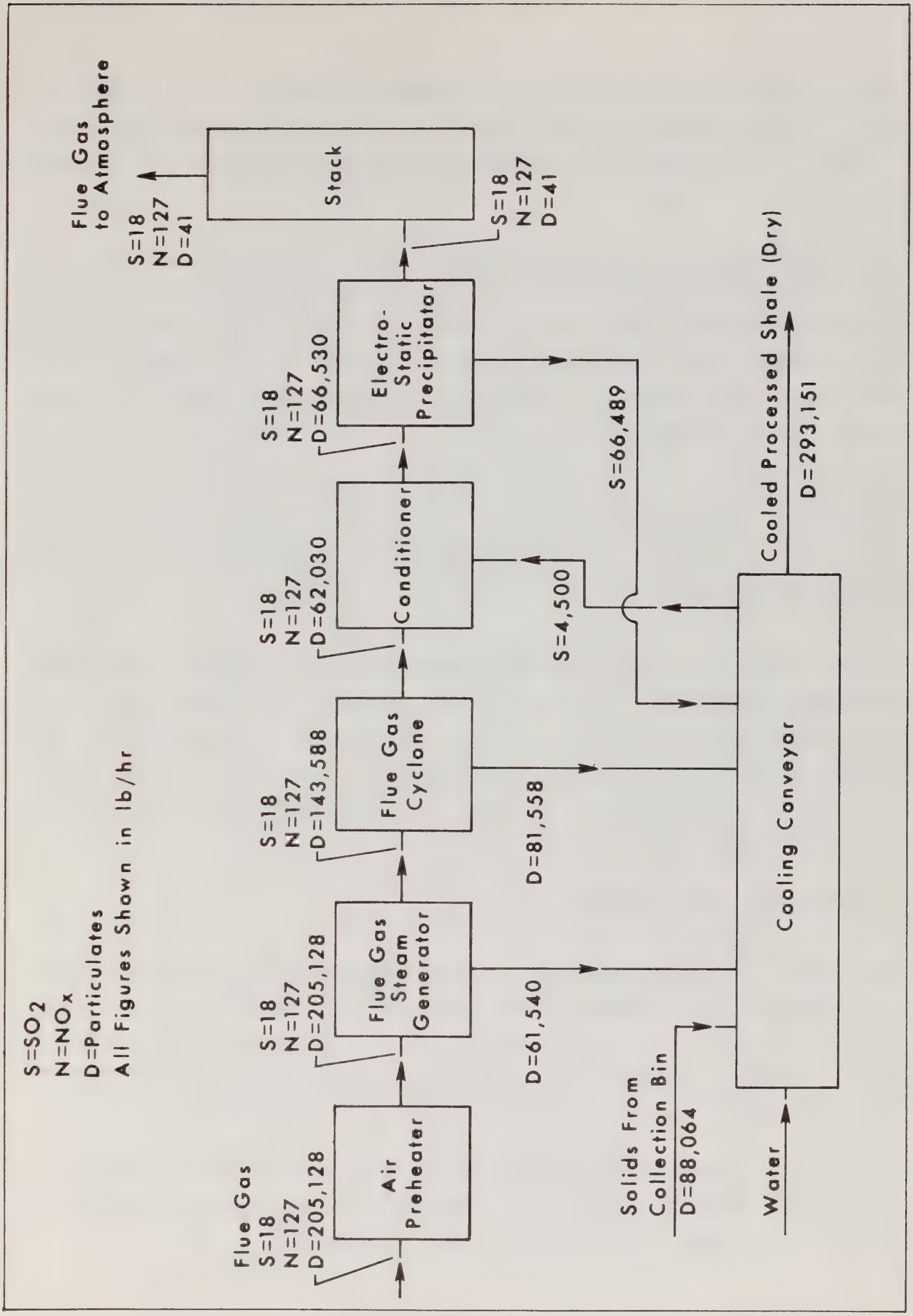



Figure 7-5-1
Concentration of Pollutants in The Flue Gas System of The Lurgi Retort

will also be optimized; however, in a commercial venture, this product will not be incinerated but rather used within the retorting/upgrading complex either as a feed material for hydrogen production or as a fuel for the total complex.

B. Support Facilities Emission Control - Support facilities that will generate atmospheric emissions include the product gas incinerator, steam generation boilers, diesel engine drives for the emergency power generator and firewater pump, the hot oil heater and emergency flare. Emissions will also occur from product oil, diesel fuel, gasoline and waste oil storage tanks due to vapor losses.

The product gas incinerator system including the $SO_2$ scrubber is described in Section 4, Chapter 3, Part 3.3. Descriptions of other emission sources are also given in Section 4, Chapter 3, Part 3.3. Storage tanks are described in Section 6, Chapter 6.

Tables 7-5-5 and 7-5-6 show the estimated emission data of the abovementioned facilities. The flare is for emergency relief and combustion of the product gas in the event that the incinerator is out-of-service. The flare system will be designed and constructed in accordance with API 520 and 521, but will not be designed for smokeless operation because it will be used only during upset conditions.

## 5.5 PROCESSED SHALE DISPOSAL

The design of the processed shale disposal operations is described and shown in Section 5. The processed shale after being moisturized will be transported from the Lurgi cooling conveyor unit to the processed shale disposal area located immediately to the north of the Lurgi plant. Covered conveyors will be used on the primary conveyor to control dust emissions.

The moisturized processed shale will be distributed into the disposal area by a stacker. Additional water can be sprayed onto the processed shale as the material is dumped into the disposal area if necessary.

Table 7-5-5

## LURGI SUPPORT FACILITIES
## ESTIMATED STACK EMISSION DATA

| Stack Description | | Production Gas Incinerator | Hot Oil Heater | Steam Boilers | Emergency Generator Diesel Drive | Firewater Pump Diesel Drive | Emergency Flare |
|---|---|---|---|---|---|---|---|
| Heat Duty (Input) | (MM Btu/hr) | 77.2 (Normal) | 5 | Two- 99 each | 12 | 1.8 | 150 |
| Fuel Type | | Product Gas | Natural Gas | Natural Gas | Diesel | Diesel | Natural Gas |
| Number of Stacks | | One | One | One(for two boilers) | One | One | One |
| Stack Height | (ft) | 310 | 50 | 100 | 20 | 20 | 75 |
| Stack Diameter | (ft) | 6.5 | 1.2 | 4.5 | 2.5 | 1.5 | 1 |
| Stack Gas Parameters: | | | | | | | |
| Flow - lb/hr | | 205,000 | 4,500 | 180,000(total) | 9,400 | 1,400 | |
| Exit Temperature | (°F) | 2201/ | 900 | 350 | 1,000 | 1,000 | (see Note 2) |
| $SO_2$ Content | (ppH) | 9.7 | -- | -- | 1.2 | 0.2 | (see Note 2) |
| $NO_x$ Content (as $NO_2$) | (ppH) | 24 | 1 | 39.6 | 41.5 | 6.2 | (see Note 2) |
| Particulates | (ppH) | -- | -- | -- | 3 | 0.5 | (see Note 2) |
| Non-methane Hydrocarbons | (ppH) | -- | -- | | 4 | 0.6 | (see Note 2) |
| CO | (ppH) | -- | -- | -- | 9 | 1.4 | (see Note 2) |
| Opacity | (%) | Under 5 | Under 5 | Under 5 | Under 10 | Under 10 | (see Note 2) |

Notes: 1/ After quench and scrubbing.
2/ For emergency only when incinerator is out-of-service. Flared gas parameters cannot be predicted.

TABLE 7-5-6

LURGI SUPPORT FACILITIES
ESTIMATED TANK VAPOR LOSSES

| Tank Description | | Product Oil Storage Tanks | Diesel Fuel Storage Tanks | Emergency Generator Diesel Fuel Tanks | Firewater Pump Diesel Fuel Tank | Gasoline Storage Tank | Waste Oil Storage Tank |
|---|---|---|---|---|---|---|---|
| Tank Service | | Product Oil | Diesel Fuel | Diesel Fuel | Diesel Fuel | Gasoline | Slop Oil |
| Tank Data | | | | | | | |
| Number | | 2 | 1 | 1 | 1 | 1 | 1 |
| Capacity - Each | (BBL) | 45,000 | 572 | 95 | 47.5 | 143 | 238 |
| Type | | Floating Roof (Insulated) | Cone Roof | Underground Horizontal | Underground Horizontal | Underground Horizontal | Floating Roof (Insulated) |
| Storage Temperature | (°F) | 100 (Heated) | Ambient | Ambient | Ambient | Ambient | 100 (Heated) |
| Annual Turnover | | 6 | 5 | 2 | 2 | 12 | Varied |
| Vapor Pressure of Contents | (psia) | 0.5 max. @ 140°F | 0.5 max. | 0.5 max. | 0.5 max. | 0.5 max. | 0.5 max. |

Other dust control measures to be employed at the processed shale disposal area are described in Section 5, Chapter 2.

## 5.6 AIR QUALITY DISPERSION MODELING

A. Modeling Methodology - Since the tract is located in an air quality attainment area, RBOSC has estimated the potential impacts to air quality according to Federal requirements for Prevention of Significant Deterioration (PSD) in compliance with Part C of the Clean Air Act.

Analyses have also been conducted to determine if ambient concentrations of pollutants in the vicinity of the project area are in compliance with National Ambient Air Quality Standards (NAAQS) and Colorado Ambient Air Quality Standards (CAAQS).

The detailed air quality assessment was based upon the current plans for the Lurgi Demonstration Project.

Stack and fugitive emission sources were included in the modeling analyses. The potential emission sources associated with the Lurgi Demonstration Project include the following:

- open pit mine
- haul road and access road
- raw shale stockpile
- wind erosion from disturbed areas
- raw shale feed preparation
- Lurgi retort and ancillary process equipment
- support facilities
- processed shale disposal and wind erosion
- hydrocarbon storage tanks

Emissions of sulfur dioxide and other gases from elevated point sources were estimated based on the normal operating conditions for the 4,400 tons per day Lurgi demonstration retort. The retort flue, incinerator/scrubber, two process steam boilers, and a hot oil heater are the sources that will emit gaseous effluents under normal operating conditions. A diesel generator, diesel pumps, and flare will emit effluents on a temporary basis during startup, shutdown, or emergency operating conditions. Stack sources were assessed with ERT Gaussian plume models, including Sequential VALLEY, and the Multiple Point Source Diffusion Model (MPSDM). Sequential VALLEY is based on the EPA VALLEY model, but rather than using the standard meteorological assumption for calculating maximum 3-hour and 24-hour concentrations (6 hours of persistent stable, low wind speed conditions), Sequential VALLEY calculates concentrations for every hour of an entire year of meteorological data and then generates consecutive 3-hour and 24-hour averages for the year. Sequential VALLEY computes concentrations at receptors specified by the user. One of the purposes for running Sequential VALLEY was to determine the concentrations of pollutants during stable conditions on high terrain near Tract C-a, specifically the Cathedral Bluffs to the west of the project area. The proper selection of input parameters for the MPSDM modeling was determined by analyzing the Sequential Valley impacts and establishing the meteorological conditions under which maximum short-term concentrations occur. Consequently, most of the receptors selected for the Sequential VALLEY modeling were to the west of the project area as shown in Figure 7-5-2. The Sequential VALLEY model assumes that during stable conditions the plume is allowed to approach the terrain to a point where the plume centerline is 10 meters above the terrain height. During unstable or neutral conditions the plume is assumed to maintain its original height above the terrain.

The MPSDM model, however, goes a step further and incorporates the concept of variable terrain correction. That is, the plume is only allowed to approach the terrain to a minimum distance equal to a fraction (called the plume height correction) of the initial plume height (stack height plus plume rise). The MPSDM modeling was performed subsequent to the Sequential VALLEY modeling in order to allow utilization of the Sequential VALLEY model results to determine appropriate values for the plume height correction parameter to be used in MPSDM.

Meteorological data gathered at Tract C-a were used as input to the Sequential VALLEY and MPSDM models. These data included surface wind speed, wind direction, and temperature. Hourly values of mixing height were estimated

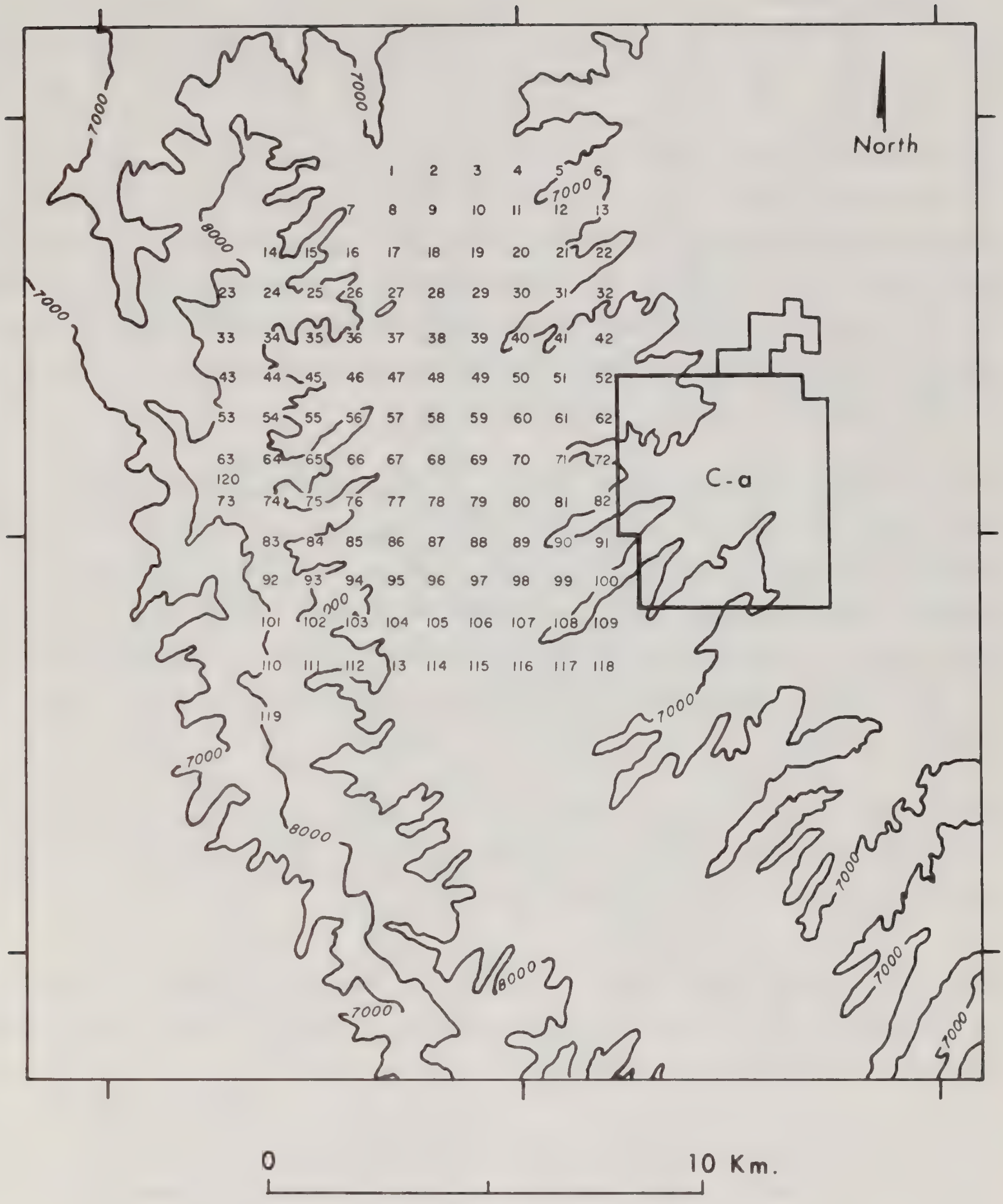



Figure 7-5-2
Receptor Layout for the Sequential Valley Modeling.

from surface wind speed values measured at RBOSC's 60-m tower and twice-daily rawinsonde observations taken in Grand Junction, Colorado. Hourly values of atmospheric stability were estimated from wind speed and temperature data measured at RBOSC's 60m tower. MPSDM was used to determine maximum Sulfur Dioxide ($SO_2$) and Total Suspended Particulate (TSP) impacts (from stack emissions only) in the area surrounding Tract C-a (Class II) and at the Flat Tops Wilderness Area (Class I). The receptor network used for MPSDM modeling is shown on Figure 7-5-3. The air quality impacts were evaluated for elevated emissions from Tract C-a alone and in combination with emissions from Tract C-b operations at 5,000 bbl/day, Colony operations at 46,000 bbl/day, and Union Oil operations at 10,000 bbl/day. Operational parameters used in the modeling of Tract C-a sources and other regional sources are shown in Tables 7-5-7 and 7-5-8, respectively.

A third model used for stack sources was the PTMTP model developed by EPA. This model was used in conjunction with the MINE model described below to estimate the maximum particulate concentrations in Class II areas due to the combined emissions from stack and fugitive sources, respectively. Detailed descriptions of the air quality models are included in the PSD application for the Lurgi Demonstration Project submitted to U.S. EPA, Region 8 on January 12, 1981.

The open pit oil shale mine, haul road and access roads, raw shale stockpile, overburden disposal, raw shale feed preparation, and processed shale disposal are the primary fugitive emission sources.

Total suspended particulates (TSP) emissions were determined by identifying all potential sources of TSP emissions and compiling a detailed emission inventory for each year of operations.

Emission factors were based on EPA Region VIII guidelines (1979), Colorado Department of Health guidelines (not dated), Wyoming Department of Environmental Quality guidelines (1979), EPA AP-42 (1977), and information obtained in various meetings with representatives of EPA Region VIII and the Colorado Department of Health. The emission inventories for 1981, 1982, 1983 and 1984 are shown in Tables 7-5-9 through 7-5-13, respectively.

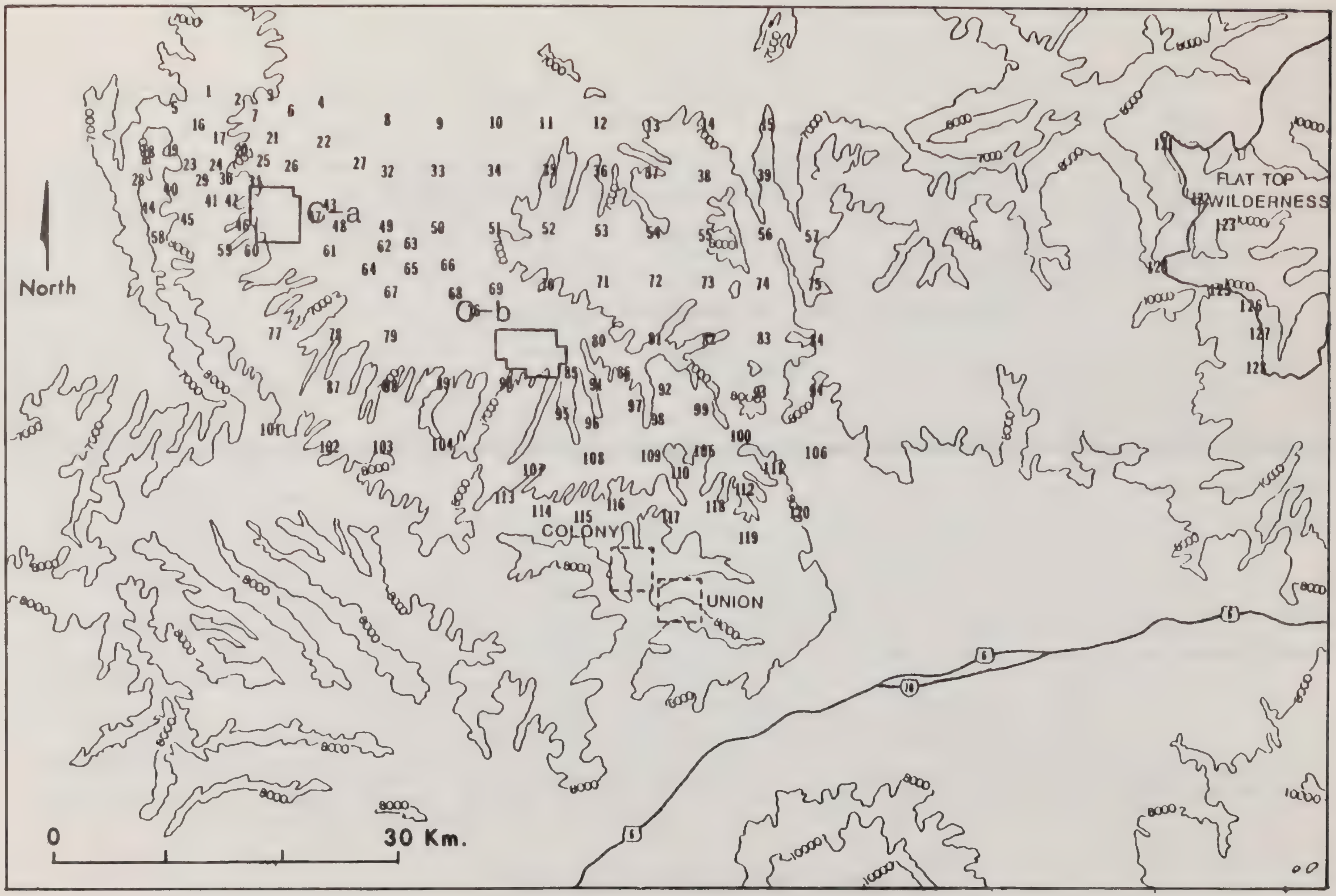



**Figure 7-5-3**
**Approximate Receptor Layout for the MPSDM Modeling.**

## TABLE 7-5-7

## LURGI AND MIS OPERATIONAL PARAMETERS

| Emission Source | Stack Height,m | Exit Temp,°K | Volumetric Flow,m3/s | UTM Coordinates X | Y | Z/ft | $SO_2$ g/sec | PM g/sec | $NO_x$ g/sec | CO g/sec | HC g/sec | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lurgi Operations | | | | | | | | | | | | |
| Lurgi Flue | 91 | 523 | 61.4 | 715.5 | 4,421.5 | 7,120 | 2.1 | 5.2 | 15.2 | 2.8 | 0.0 | |
| Product Gas Incinerator/ Scrubber | 76 | 355 | 30.6 | 715.5 | 4,421.5 | 7,120 | 1.3 | 0.0 | 2.1 | 0.0 | 0.0 | normal capacity |
| 2 Process Steam Boilers | 31 | 450 | 28.3 | 715.5 | 4,421.5 | 7,120 | 0.0 | 0.0 | 3.7 | 0.0 | 0.0 | maximum capacity |
| Hot Oil Heater | 15 | 755 | 1.6 | 715.5 | 4,421.5 | 7,120 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | |
| MIS Operations | | | | | | | | | | | | |
| Incinerator/Scrubber | 60 | 353 | 106.5 | 715.0 | 4,424.0 | 6,600 | 8.6 | 1.4 | 23.0 | 4.7 | 0.8 | normal capacity |
| Process Steam Boiler | 30 | 450 | 14.8 | 715.0 | 4,424.0 | 6,600 | 2.1 | 0.1 | 5.2 | 0.1 | 0.04 | normal capacity |

## TABLE 7-5-8

## OPERATIONAL PARAMETERS FOR OTHER PSD SOURCES

| Emission Source | Stack Height,m | Exit Temp,°K | Volumetric Flow,$m^3$/s | UTM Coordinates X | Y | Z/ft | $SO_2$ g/sec | PM g/sec | $NO_x$ g/sec | CO g/sec | HC g/sec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| C-b MIS-5,000 bbl/day | 30 | 477 | 143.5 | 739.8 | 4,408.7 | 6,800 | 3.5 | 5.0 | 56.2 | 488.4 | 3.1 |
| Colony - 46,000 bbl/day | 77 | 381 | 42.2 | 747.2 | 4,388.5 | 7,500 | 41.4 | 32.1 | 220.0 | 8.7 | 38.2 |
| Union Oil - 10,000 bbl/day | 52 | 769 | 61.5 | 751.5 | 4,386.7 | 7,200 | 12.8 | 27.2 | 11.1 | 16.4 | 5.5 |

TABLE 7-5-9

TRACT C-a LURGI DEMONSTRATION PROJECT FUGITIVE DUST INVENTORY
CONSTRUCTION PHASE-MAY 1981 THROUGH AUGUST 1981

| Fugitive Dust Source | Emission Factor | Operational Parameter | Control Technique | Percent Control | NAAQS Emission Rate[2] | | PSD Emission Rate[2] | |
|---|---|---|---|---|---|---|---|---|
| | | | | | g/sec | ton/4mos | g/sec | ton/4 mos |
| Topsoil Removal | 0.38 lb/$yd^3$ | 505,700 $yd^3$/4 mos | watering | 50 | 5.81 | 48.04 | 0.56 | 4.61 |
| Topsoil Haul | 0.703 lb/VMT | 12,800 VMT/4 mos | watering | 50 | 0.27 | 2.25 | 0.03 | 0.22 |
| Water Truck Traffic | 1.22 lb/VMT | 3,480 VMT/4 mos | watering | 50 | 0.13 | 1.06 | 0.00 | 0.00 |
| Access Road Traffic[1] | 3.05 lb/VMT | 311 VMT/day | 90% compaction | 80 | 1.00 | 4.13 | 0.50 | 2.07 |
| Access Road Construction[1] | 32 lb/grader-hr | 520 grader hrs/ 4 mos | watering | 50 | 1.01 | 4.16 | 0.00 | 0.00 |
| Topsoil Erosion | 0.0712 tons/ acre-yr | 40 acres | rapid vegetation | 75 | 0.08 | 0.24 | 0.08 | 0.24 |
| Concrete Batch Plant | | | | | | | | |
| sand and aggregate transfer to elevated bins | 0.04 lb/ton | 268.5 ton/day | baghouse | 99 | 0.00 | 0.00 | 0.00 | 0.00 |
| cement unloading to elevated storage silos | 0.23 lb/ton | 41.5 ton/day | baghouse | 99 | 0.00 | 0.00 | 0.00 | 0.00 |
| weight hopper loading of cement, sand, and aggregate | 0.23 lb/ton | 310 ton/day | baghouse | 99 | 0.00 | 0.03 | 0.00 | 0.00 |
| mixer loading of cement, sand, and aggregate | 0.02 lb/ton | 310 ton/day | baghouse | 99 | 0.00 | 0.00 | 0.00 | 0.00 |
| loading of transit mix truck | 0.02 lb/ton | 324 ton/day | none | 0 | 0.04 | 0.28 | 0.00 | 0.00 |
| Topsoil Dumping | 0.03 lb/$yd^3$ | 505,700 $yd^3$/4 mos | watering | 50 | 0.46 | 3.80 | 0.04 | 0.36 |
| TOTAL | | | | | 7.80 | 63.99 | 1.21 | 7.50 |

[1] These two operations cannot occur simultaneously. The total short term emissions reflect access road construction.

[2] Controlled emission data

## TABLE 7-5-10

### TRACT C-a LURGI DEMONSTRATION PROJECT FUGITIVE DUST INVENTORY OVERBURDEN STRIPPING PHASE-SEPTEMBER 1981 THROUGH DECEMBER 1981

| Fugitive Dust Source | Emission Factor | Operational Parameter | Control Technique | Percent Control | NAAQS Emission Rate[2] g/sec | NAAQS Emission Rate[2] ton/4mos | PSD Emission Rate[2] g/sec | PSD Emission Rate[2] ton/4 mos |
|---|---|---|---|---|---|---|---|---|
| Overburden Removal | 0.0069 lb/ton | 4,557,390 ton/4 mos | none | 0 | 1.90 | 15.72 | 1.34 | 11.07 |
| Overburden Haul | 1.64 lb/VMT | 69,615 VMT/4 mos | LS[1] | 85 | 1.04 | 8.61 | 0.00 | 0.00 |
| Water Truck Traffic | 1.22 lb/VMT | 1,740 VMT/4 mos | LS[1] | 85 | 0.03 | 0.29 | 0.00 | 0.00 |
| Access Road Traffic | 3.05 lb/VMT | 311 VMT/day | 90% compaction & LS[1] | 80 & 85 | 0.15 | 1.24 | 0.08 | 0.62 |
| Overburden Dumping | 0.02 lb/ton | 4,557,390 ton/4 mos | none | 0 | 5.51 | 45.57 | 0.00 | 0.00 |
| Haul Road Construction | 32 lb/grader-hr | 1,577 grader hr/4mos | watering | 50 | 1.75 | 12.62 | 0.00 | 0.00 |
| Concrete Batch Plant | | | | | | | | |
| sand and aggregate transfer to elevated bins | 0.04 lb/ton | 268.5 ton/day | baghouse | 99 | 0.00 | 0.00 | 0.00 | 0.00 |
| cement unloading to elevated storage silos | 0.23 lb/ton | 41.5 ton/day | baghouse | 99 | 0.00 | 0.00 | 0.00 | 0.00 |
| weight hopper loading of cement, sand, and aggregate | 0.23 lb/ton | 310 ton/day | baghouse | 99 | 0.00 | 0.03 | 0.00 | 0.00 |
| mixer loading of cement, sand, and aggregate | 0.02 lb/ton | 310 ton/day | baghouse | 99 | 0.00 | 0.00 | 0.00 | 0.00 |
| loading of transit mix trucks | 0.02 lb/ton | 324 ton/day | none | 0 | 0.04 | 0.28 | 0.00 | 0.00 |
| Drilling | 1.5 lb/hole | 675 holes/mo | water injection | 90 | 0.02 | 0.20 | 0.02 | 0.20 |
| Blasting | 50 lb/blast | 17 blast/mo | none | 0 | 0.20 | 1.69 | 0.20 | 1.69 |
| Topsoil Erosion | 0.0712 tons/acre-yr | 40 acres | rapid vegetation | 75 | 0.08 | 0.24 | 0.08 | 0.24 |
| Overburden Erosion | 0.0576 tons/acre-yr | 71 acres | none | 0 | 0.12 | 1.36 | 0.12 | 1.36 |
| Disturbed Areas Erosion | 0.0576 tons/acre-yr | 301 acres | none | 0 | 0.50 | 5.78 | 0.50 | 5.78 |
| TOTAL | | | | | 11.34 | 93.63 | 2.34 | 20.96 |

1/ LS - Lignon Sulfonate or other dust palliative
2/ Controlled emissions

TABLE 7-5-11

TRACT C-a LURGI DEMONSTRATION PROJECT FUGITIVE DUST INVENTORY
1982 OPERATIONS

| Fugitive Dust Source | Emission Factor | Operational Parameter | Control Technique | Percent Control | NAAQS Emission Rate[2/] g/sec | NAAQS Emission Rate[2/] ton/yr | PSD Emission Rate[2/] g/sec | PSD Emission Rate[2/] ton/yr |
|---|---|---|---|---|---|---|---|---|
| Overburden Removal | 0.0069 lb/ton | 6,015,200 ton/yr | none | 0 | 0.84 | 20.75 | 0.84 | 20.75 |
| Overburden Haul | 1.65 lb/VMT | 247,038 VMT/yr | LS[1/] | 85 | 1.23 | 30.57 | 0.00 | 0.00 |
| Overburden Dumping | 0.02 lb/ton | 6,015,200 ton/yr | none | 0 | 2.42 | 60.15 | 0.00 | 0.00 |
| Topsoil Removal | 0.38 lb/yd³ | 252,500 yd³/yr | watering | 50 | 0.97 | 23.99 | 0.00 | 0.00 |
| Topsoil Haul | 0.703 lb/VMT | 6,391 VMT/yr | LS[1/] | 85 | 0.01 | 0.34 | 0.00 | 0.00 |
| Topsoil Dumping | 0.03 lb/yd³ | 252,500 yd³/yr | watering | 50 | 0.08 | 1.90 | 0.00 | 0.00 |
| Access Road Traffic | 3.05 lb/VMT | 311 VMT/day | 90% compaction & LS[1/] | 80 & 85 | 0.15 | 3.71 | 0.12 | 2.97 |
| Water Truck Traffic[3/] | 1.22 lb/VMT<br>0.49 lb/VMT | 5,220 VMT/yr<br>10,440 VMT/yr | LS[1/] | 85 | 0.03 | 0.86 | 0.00 | 0.00 |
| Drilling | 1.5 lb/hole | 675 holes/mo | water injection | 90 | 0.02 | 0.61 | 0.02 | 0.61 |
| Blasting | 50 lb/blast | 17 blasts/mo | none | 0 | 0.20 | 5.07 | 0.20 | 5.07 |
| Concrete Batch Plant | | | | | | | | |
| sand and aggregrate transfer to elevated bins | 0.04 lb/ton | 268.5 ton/day | baghouse | 99 | 0.00 | 0.00 | 0.00 | 0.00 |
| cement unloading to elevated storage silos | 0.23 lb/ton | 4.15 ton/day | baghouse | 99 | 0.00 | 0.00 | 0.00 | 0.00 |
| weight hopper loading of cement, sand, and aggregate | 0.23 lb/ton | 310 ton/day | baghouse | 99 | 0.00 | 0.12 | 0.00 | 0.00 |
| mixer loading of cement, sand, and aggregate | 0.02 lb/ton | 310 ton/day | baghouse | 99 | 0.00 | 0.00 | 0.00 | 0.00 |
| loading of transit mix truck | 0.02 lb/ton | 324 ton/day | none | 0 | 0.04 | 0.85 | 0.00 | 0.00 |

## TABLE 7-5-11 (CONTINUED

## TRACT C-a LURGI DEMONSTRATION PROJECT FUGITIVE DUST INVENTORY 1982 OPERATIONS

| Fugitive Dust Source | Emission Factor | Operational Parameter | Control Technique | Percent Control | NAAQS Emission Rate 2/ | | PSD Emission Rate 2/ | |
|---|---|---|---|---|---|---|---|---|
| | | | | | g/sec | ton/4mos | g/sec | ton/4 mos |
| Topsoil Erosion | 0.0712 ton/ acre-yr | 60 acres | rapid vegetation | 75 | 0.03 | 1.07 | 0.03 | 1.07 |
| Overburden Erosion | 0.0576 tons/ acre-yr | 167 acres | none | 0 | 0.28 | 9.56 | 0.28 | 9.56 |
| Disturbed Areas Erosion | 0.0576 tons/ acre-yr | 301 acres | none | 0 | 0.50 | 17.34 | 0.50 | 17.34 |
| TOTAL | | | | | 6.80 | 176.89 | 1.99 | 57.37 |

1/ LS - Lignon Sulfonate or other dust palliative

2/ Controlled emissions as applicable

3/ Two different sizes of water trucks will be used

# TABLE 7-5-12

## TRACT C-a LURGI DEMONSTRATION PROJECT FUGITIVE DUST INVENTORY 1983 OPERATIONS

| Fugitive Dust Source | Emission Factor | Operational Parameter | Control Technique | Percent Control | NAAQS Emission Rate 2/ | | PSD Emission Rate 2/ | |
|---|---|---|---|---|---|---|---|---|
| | | | | | g/sec | ton/yr | g/sec | ton/yr |
| Overburden Removal | 0.0069 lb/ton | 2,483,600 $yd^3$/yr | none | 0 | 0.63 | 15.64 | 0.63 | 15.64 |
| Overburden Haul | 1.65 lb/VMT | 25,481 VMT/yr | LS 1/ | 85 | 0.13 | 3.15 | 0.04 | 0.87 |
| Overburden Dumping | 0.02 lb/ton | 2,483,600 $yd^3$/yr | none | 0 | 1.83 | 45.33 | 1.61 | 39.98 |
| Topsoil Removal | 0.38 lb/$yd^3$ | 16,900 $yd^3$/yr | watering | 50 | 0.06 | 1.61 | 0.06 | 1.61 |
| Topsoil Haul | 0.703 lb/VMT | 414 VMT/yr | LS 1/ | 85 | 0.00 | 0.02 | 0.00 | 0.02 |
| Topsoil Dumping | 0.03 lb/$yd^3$ | 16,900 $yd^3$/yr | Watering | 50 | 0.01 | 0.13 | 0.01 | 0.13 |
| Ore Removal | 0.000069 lb/ton | 1,200,000 ton/yr | none 3/ | 0 | 0.00 | 0.04 | 0.00 | 0.04 |
| Ore Haul | 1.65 lb/VMT | 41,332 VMT/yr | LS 1/ | 85 | 0.21 | 5.12 | 0.21 | 5.12 |
| Ore Dumping | 0.000069 lb/ton | 1,200,00 ton/yr | none 3/ | 0 | 0.00 | 0.04 | 0.00 | 0.04 |
| Water Truck Traffic | 1.22 lb/VMT<br>0.49 lb/VMT | 5,220 VMT/yr<br>10,440 VMT/yr | LS 1/ | 85 | 0.03 | 0.86 | 0.03 | 0.86 |
| Access Road Traffic | 3.05 lb/VMT | 311 VMT/day | 90% compaction & LS 1/ | 80 & 85 | 0.15 | 3.71 | 0.15 | 3.71 |
| Topsoil Erosion | 0.0712 tons/ acre-yr | 60 acres | rapid revegetation | 75 | 0.03 | 1.07 | 0.03 | 1.07 |
| Overburden Erosion | 0.0576 tons/ acre-yr | 167 acres | rapid revegetation | 75 | 0.07 | 2.39 | 0.07 | 2.39 |
| Ore Stockpile Erosion | 0.00758 tons/ acre-yr | 29 acres | none | 0 | 0.01 | 0.22 | 0.01 | 0.22 |
| Ore and Overburden Drilling | 1.5 lb/hole | 675 holes/mo | water injection | 90 | 0.02 | 0.61 | 0.02 | 0.61 |
| Ore and Overburden Blasting | 50 lb/blast | 17 blast/mo | stemming in wet holes | 50 | 0.10 | 2.54 | 0.10 | 2.54 |
| Disturbed Areas Erosion | 0.0576 ton/ acres-yr | 301 acres | none | 0 | 0.50 | 17.34 | 0.50 | 17.34 |
| Run of Mine Ore Load Out From Ore Stockpile | 0.0011 lb/ton | 4,400 ton/day | none | 0 | 0.03 | 0.44 | 0.03 | 0.44 |
| Run of Mine Ore Load In to Primary Crusher Hopper | 0.0022 lb/ton | 4,400 ton/day | none | 0 | 0.05 | 0.88 | 0.05 | 0.88 |

## TABLE 7-5-12 (CONTINUED)

| Fugitive Dust Source | Emission Factor | Operational Parameter | Control Technique | Percent Control | NAAQS Emission Rate[2] | | PSD Emission Rate[2] | |
|---|---|---|---|---|---|---|---|---|
| | | | | | g/sec | ton/year | g/sec | ton/yr |
| Primary Crushing/Screening | 0.12 lb/ton | 4,400 ton/day | baghouse | 99 | 0.03 | 0.48 | 0.03 | 0.48 |
| Secondary Crushing/Screening | 0.16 lb/ton | 4,400 ton/day | baghouse | 99 | 0.04 | 0.64 | 0.04 | 0.64 |
| Crushed Ore Conveying to Stockpile Building | 0.20 lb/ton | 4,400 ton/day | baghouse | 99 | 0.05 | 0.80 | 0.05 | 0.80 |
| Crushed Ore Load Out From Stockpile Building | 0.05 lb/ton | 4,400 ton/day | baghouse | 99 | 0.01 | 0.20 | 0.01 | 0.20 |
| Crushed Ore Conveying to Feed Hopper Upstream of Belt Conveyer | 0.20 lb/ton | 4,400 ton/day | baghouse | 99 | 0.05 | 0.80 | 0.05 | 0.80 |
| Crushed Ore Transfer to Lurgi Feed Hopper Via Belt Conveyer | 0.20 lb/ton | 4,400 ton/day | baghouse | 99 | 0.05 | 0.80 | 0.05 | 0.80 |
| Processed Shale Transfer Via Rotary Feeder and Conveyor | 0.20 lb/ton | 4,400 ton/day | baghouse | 99 | 0.05 | 0.80 | 0.05 | 0.80 |
| Processed Shale Transfer From Hopper to Processed Shale Disposal Area | 0.20 lb/ton | 4,400 ton/day | baghouse | 99 | 0.05 | 0.80 | 0.05 | 0.80 |
| Processed Shale Disposal Via Stacker in Processed Shale Disposal Area | 0.20 lb/ton | 4,400 ton/day | moisturized processed shale | 90 | 0.46 | 8.03 | 0.46 | 8.03 |
| Processed Shale Erosion | 0.0576 tons/acre-yr | 30 acres | chemical bonding of wet spent shale | none | 0.05 | 1.73 | 0.05 | 1.73 |
| TOTAL | | | | | 4.70 | 116.22 | 4.39 | 108.59 |

[1]LS - Lignon Sulfonate or other dust palliative

[2]Controlled emissions

[3]No specific controls are planned. However, the ore is associated with an aquifer and will be saturated with water

TABLE 7-5-13

## TRACT C-a LURGI DEMONSTRATION PROJECT FUGITIVE DUST INVENTORY 1984 OPERATIONS

| Fugitive Dust Source | Emission Factor | Operational Parameter | Control Technique | Percent Control | NAAQS Emission Rate[2/] g/sec | NAAQS Emission Rate[2/] ton/yr | PSD Emission Rate[2/] g/sec | PSD Emission Rate[2/] ton/4 mos |
|---|---|---|---|---|---|---|---|---|
| Overburden Removal | 0.0069 lb/ton | 1,957,000 $yd^3$/yr | none | 0 | 0.50 | 12.32 | 0.50 | 12.32 |
| Overburden Haul | 1.65 lb/VMT | 108,530 VMT/yr | LS[1/] | 85 | 0.54 | 13.43 | 0.00 | 0.10 |
| Overburden Dumping | 0.02 lb/ton | 1,957,000 $yd^3$/yr | none | 0 | 1.44 | 31.28 | 0.18 | 4.44 |
| Topsoil Removal | 0.38 lb/$yd^3$ | 253,100 $yd^3$/yr | watering | 50 | 0.97 | 24.05 | 0.35 | 8.64 |
| Topsoil Haul | 0.703 lb/VMT | 5,821 VMT/yr | LS[1/] | 85 | 0.01 | 0.31 | 0.00 | 0.11 |
| Topsoil Dumping | 0.03 lb/$yd^3$ | 253,100 $yd^3$/yr | watering | 50 | 0.08 | 1.70 | 0.03 | 0.68 |
| Ore Removal | 0.000069 lb/ton | 1,800,000 ton/yr | none[3/] | 0 | 0.00 | 0.06 | 0.00 | 0.06 |
| Ore Haul | 1.65 lb/VMT | 61,998 VMT/yr | LS[1/] | 85 | 0.31 | 7.67 | 0.31 | 7.67 |
| Ore Dumping | 0.000069 lb/ton | 1,800,000 ton/yr | none[3/] | 0 | 0.00 | 0.06 | 0.00 | 0.06 |
| Water Truck Traffic | 1.22 lb/VMT<br>0.49 lb/VMT | 5,220 VMT/yr<br>10,440 VMT/yr | LS[1/] | 85 | 0.03 | 0.86 | 0.03 | 0.86 |
| Access Road Traffic | 3.05 lb/VMT | 311 VMT/day | 90% compaction & LS[1/] | 80 & 85 | 0.15 | 3.71 | 0.15 | 3.71 |
| Topsoil Erosion | 0.0712 tons/acre-yr | 60 acres | rapid revegetation | 75 | 0.03 | 1.07 | 0.03 | 1.07 |
| Overburden Erosion | 0.0576 tons/acre-yr | 167 acres | rapid revegetation | 75 | 0.07 | 2.39 | 0.07 | 2.39 |
| Ore Stockpile Erosion | 0.00758 tons/acre-yr | 43 acres | none | 0 | 0.01 | 0.33 | 0.01 | 0.33 |
| Ore and Overburden Drilling | 1.5 lb/hole | 675 holes/mo | water injection | 90 | 0.02 | 0.61 | 0.02 | 0.61 |
| Ore and Overburden Blasting | 50 lb/blast | 17 blast/mo | stemming in wet holes | 50 | 0.10 | 2.54 | 0.10 | 2.54 |
| Disturbed Areas Erosion | 0.0576 ton/acres-yr | 301 acres | none | 0 | 0.50 | 17.34 | 0.50 | 17.34 |
| Run of Mine Ore Load Out From Ore Stockpile | 0.0011 lb/ton | 4,400 ton/day | none | 0 | 0.03 | 0.44 | 0.03 | 0.44 |
| Run of Mine Ore Load In to Primary Crusher Hopper | 0.0022 lb/ton | 4,400 ton/day | none | 0 | 0.05 | 0.88 | 0.05 | 0.88 |

## TABLE 7-5-13 (CONTINUED)

| Fugitive Dust Source | Emission Factor | Operational Parameter | Control Technique | Percent Control | NAAQS Emission Rate[2] g/sec | NAAQS Emission Rate[2] ton/yr | PSD Emission Rate[2] g/sec | PSD Emission Rate[2] ton/yr |
|---|---|---|---|---|---|---|---|---|
| Primary Crushing/Screening | 0.12 lb/ton | 4,400 ton/day | baghouse | 99 | 0.03 | 0.48 | 0.03 | 0.48 |
| Secondary Crushing/Screening | 0.16 lb/ton | 4,400 ton/day | baghouse | 99 | 0.04 | 0.64 | 0.04 | 0.64 |
| Crushed Ore Conveying to Stockpile Building | 0.20 lb/ton | 4,400 ton/day | baghouse | 99 | 0.05 | 0.80 | 0.05 | 0.80 |
| Crushed Ore Load Out From Stockpile Building | 0.05 lb/ton | 4,400 ton/day | baghouse | 99 | 0.01 | 0.20 | 0.01 | 0.20 |
| Crushed Ore Conveying to Feed Hopper Upstream of Belt Conveyer | 0.20 lb/ton | 4,400 ton/day | baghouse | 99 | 0.05 | 0.80 | 0.05 | 0.80 |
| Crushed Ore Transfer to Lurgi Feed Hopper Via Belt Conveyer | 0.20 lb/ton | 4,400 ton/day | baghouse | 99 | 0.05 | 0.80 | 0.05 | 0.80 |
| Processed Shale Transfer Via Rotary Feeder and Conveyor | 0.20 lb/ton | 4,400 ton/day | baghouse | 99 | 0.05 | 0.80 | 0.05 | 0.80 |
| Processed Shale Transfer From Hopper to Processed Shale Disposal Area | 0.20 lb/ton | 4,400 ton/day | baghouse | 99 | 0.05 | 0.80 | 0.05 | 0.80 |
| Processed Shale Disposal Via Stacker in Processed Shale Disposal Area | 0.20 lb/ton | 4,400 ton/day | moisturized processed shale | 90 | 0.46 | 8.03 | 0.46 | 8.03 |
| Processed Shale Erosion | 0.0576 tons/ acre-yr | 30 acres | chemical bonding of wet spent shale | none | 0.05 | 1.73 | 0.05 | 1.73 |
| TOTAL | | | | | 5.68 | 136.13 | 3.20 | 79.33 |

[1] LS - Lignon Sulfonate or other dust palliative

[2] Controlled emissions

[3] No specific controls are planned. However, the ore is associated with an aquifer and will be saturated with water

For purposes of determining PSD increment consumption, the emissions of TSP from construction-related activities were not considered because these activities are temporary and short-term. Construction-related emissions were considered, however, in determining compliance with Colorado Ambient Air Quality Standards (CAAQS).

From the TSP emission inventory, it is projected that the highest emission rate for operational activities will occur in 1983 (Table 7-5-12). However, when emissions from construction-related activities are included with the operational sources, the highest short-term emissions are projected to occur in 1981 (Table 7-5-10) and the highest annual emissions are anticipated in 1982 (Table 7-5-11). Thus, modeling to determine maximum PSD increment consumption was conducted for the 1983 operational scenario. Modeling to determine compliance with Federal and State ambient air quality standards used 1981 emission estimates to determine the maximum 24-hour concentrations and 1982 emissions to estimate highest average annual concentration.

The MINE Model was used to estimate TSP ground level concentrations resulting from fugitive emission sources. This model was specifically designed to simulate the dispersion of point, line and area fugitive dust sources, such as those occurring from a surface mine. The receptor network used to predict TSP concentrations at and beyond the Tract C-a boundary are shown in Figure 7-5-4.

There is no treatment for plume rise incorporated in the MINE model. The model does, however, contain a detailed treatment for particle deposition using the deposition equation of Ermak (1977). This routine is based on a theoretical solution of the differential equations which describe atmospheric diffusion. It contains a removal mechanism for particulates by both gravitational settling and turbulent diffusion to the surface with subsequent removal by impaction.

B. Modeling Results - The air quality analysis discussed in this document was conducted to comply with Part C of the Clean Air Act in determining the consumption by the Lurgi Demonstration Project of Class I and II PSD increments. At present, PSD increments have only been established for sulfur

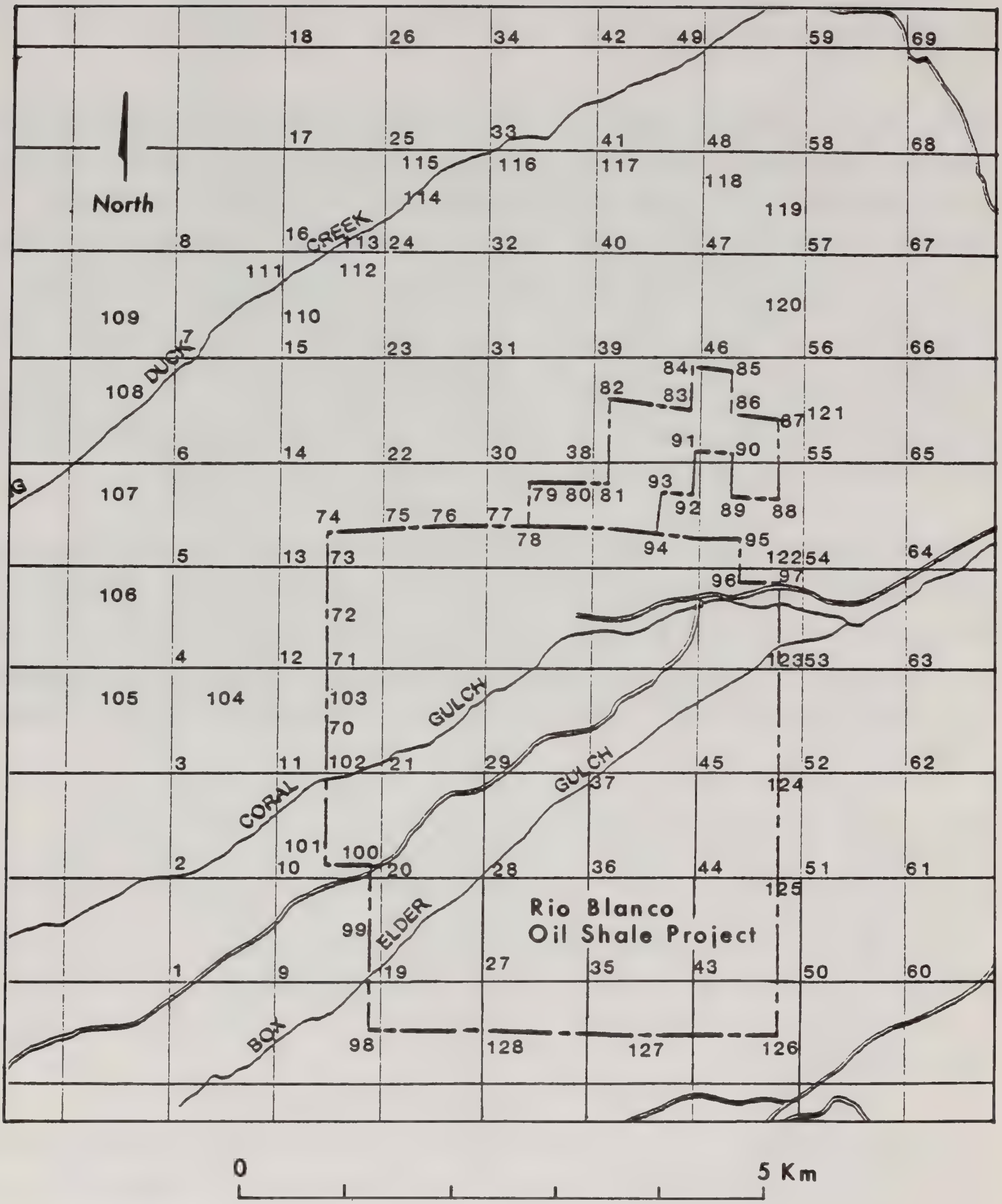



**Figure 7-5-4**
**Receptor Locations for the Mine Modeling of TSP**

dioxide ($SO_2$) and total suspended particulates (TSP). Table 7-5-14 shows the appropriate PSD increments for Class I and Class II areas. Tract C-a is in a Class II area. The Class I increments apply in areas of special air quality concern, such as National Parks and Wilderness areas. The only nearby Class I area is the Flat Tops Wilderness, located about 80 kilometers east of Tract C-a.

TABLE 7-5-14

PSD INCREMENTS IN $\mu g/m^3$

| Pollutant | Class I | Class II |
|---|---|---|
| Sulfur dioxide ($SO_2$) | | |
| 3-hour | 25 | 512 |
| 24-hour | 5 | 91 |
| annual | 2 | 20 |
| Total Suspended Particulate (TSP) | | |
| 24-hour | 10 | 37 |
| annual | 5 | 19 |

1. Consumption of Class II $SO_2$ Increment - The impacts of the project on ambient $SO_2$ concentrations were analyzed using the elevated point source models, Sequential VALLEY and MPSDM. The results of the Sequential VALLEY modeling are presented both in graphical and tabular form. Table 7-5-15 presents a summary of the highest and second highest 3-hour, 24-hour, and annual-average concentrations calculated by the model. Model results are given for the Lurgi project alone and the Lurgi combined with the other identified regional sources of $SO_2$. Table 7-5-15 also shows that all predicted concentrations are below the Class II PSD increments for $SO_2$. The highest and second highest 3-hour concentrations both resulted from stable, low wind speed meteorological conditions with the wind directed to the west towards Cathedral Bluffs. The same is true of the maximum 24-hour values. These results indicate that stable, low wind speed conditions directed at nearby high terrain may cause the greatest air quality impacts due to emissions from the C-a elevated stacks.

Model results shown in Table 7-5-15 indicate that the ground level pollutants at Cathedral Bluffs are almost entirely due to the C-a sources alone. The combined concentrations from Tract C-a with other sources in the area are only slightly greater than those of Tract C-a alone. This results from the proximity of Tract C-a to the critical receptors.

Table 7-5-15

SUMMARY OF MAXIMUM $SO_2$ CONCENTRATIONS CALCULATED BY SEQUENTIAL VALLEY FOR CLASS II AREAS

| | Highest $SO_2$ Concentration | | Second Highest $SO_2$ Concentration | | Class II PSD Increment |
|---|---|---|---|---|---|
| | Value ($\mu g/m^3$) | Receptor | Value ($\mu g/m^3$) | Receptor | ($\mu g/m^3$) |
| Tract C-a Alone | | | | | |
| 3-hour | 65.1 | 82 | 62.0 | 82 | 512 |
| 24-hour | 22.9 | 91 | 22.3 | 82 | 91 |
| Annual | 2.0 | 72 | 1.5 | 82 | 20 |
| All Sources | | | | | |
| 3-hour | 65.1 | 82 | 62.0 | 82 | 512 |
| 24-hour | 23.1 | 91 | 22.4 | 82 | 91 |
| Annual | 2.0 | 72 | 1.5 | 82 | 20 |

The spatial distribution of Sequential VALLEY modeling results for Tract C-a sources alone is shown in Figures 7-5-5, 7-5-6, and 7-5-7. Figure 7-5-5 is a plot of annual average isopleths of $SO_2$ concentration. Figures 7-5-6 and 7-5-7, however, are not isopleths per se but are plots of the maximum $SO_2$ concentration at each receptor for the 3-hour and 24-hour averaging times. Since these concentrations do not necessarily occur at each receptor during the same averaging period, the figures are called "zones of influence" rather than isopleths. As the figures depict, the concentrations are low and are confined to a small area.

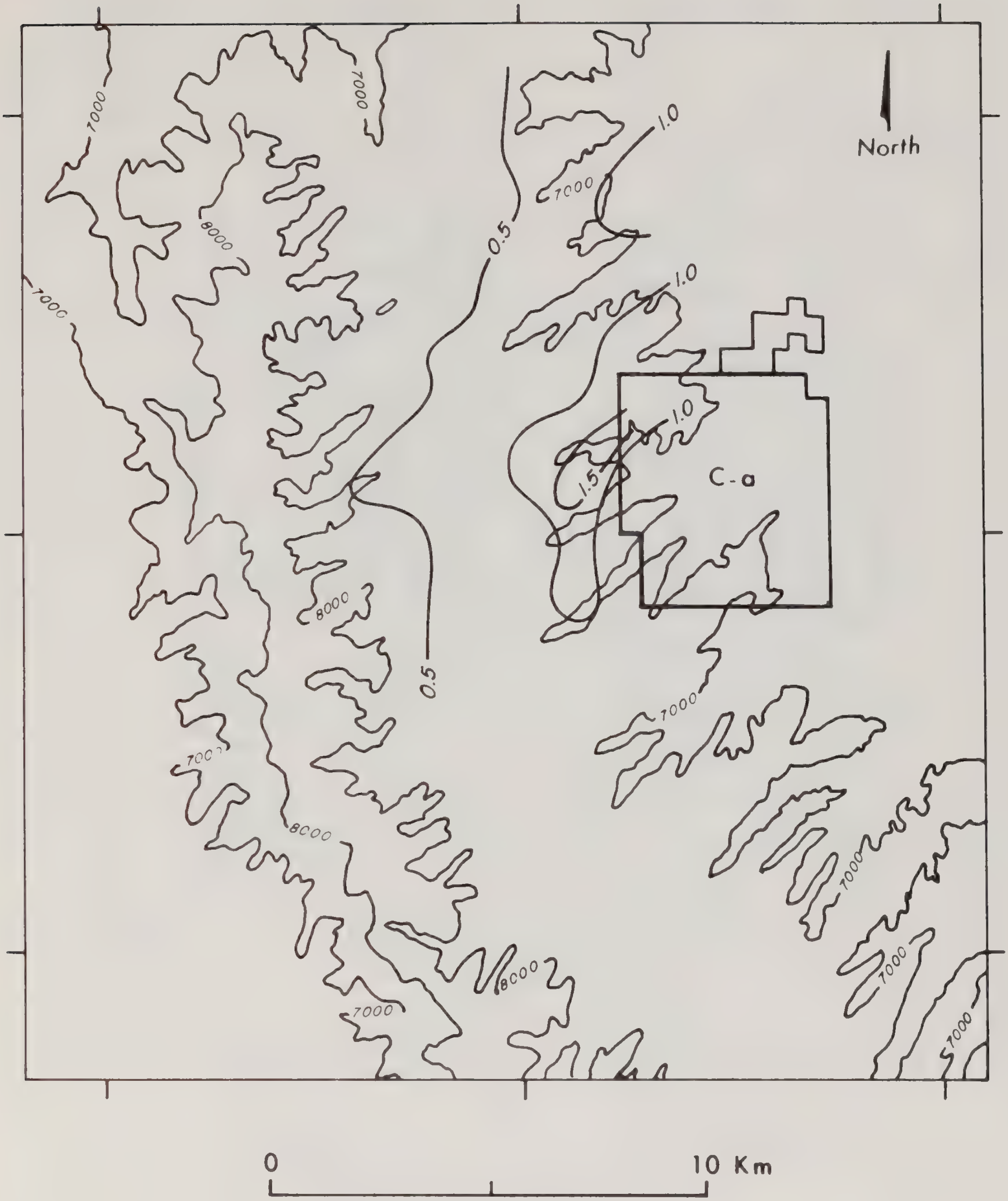



Figure 7-5-5
Isopleths of Annual-Average $SO_2$ Concentration in ug/$m^3$ as Predicted by Sequential Valley for the C-a Sources Alone

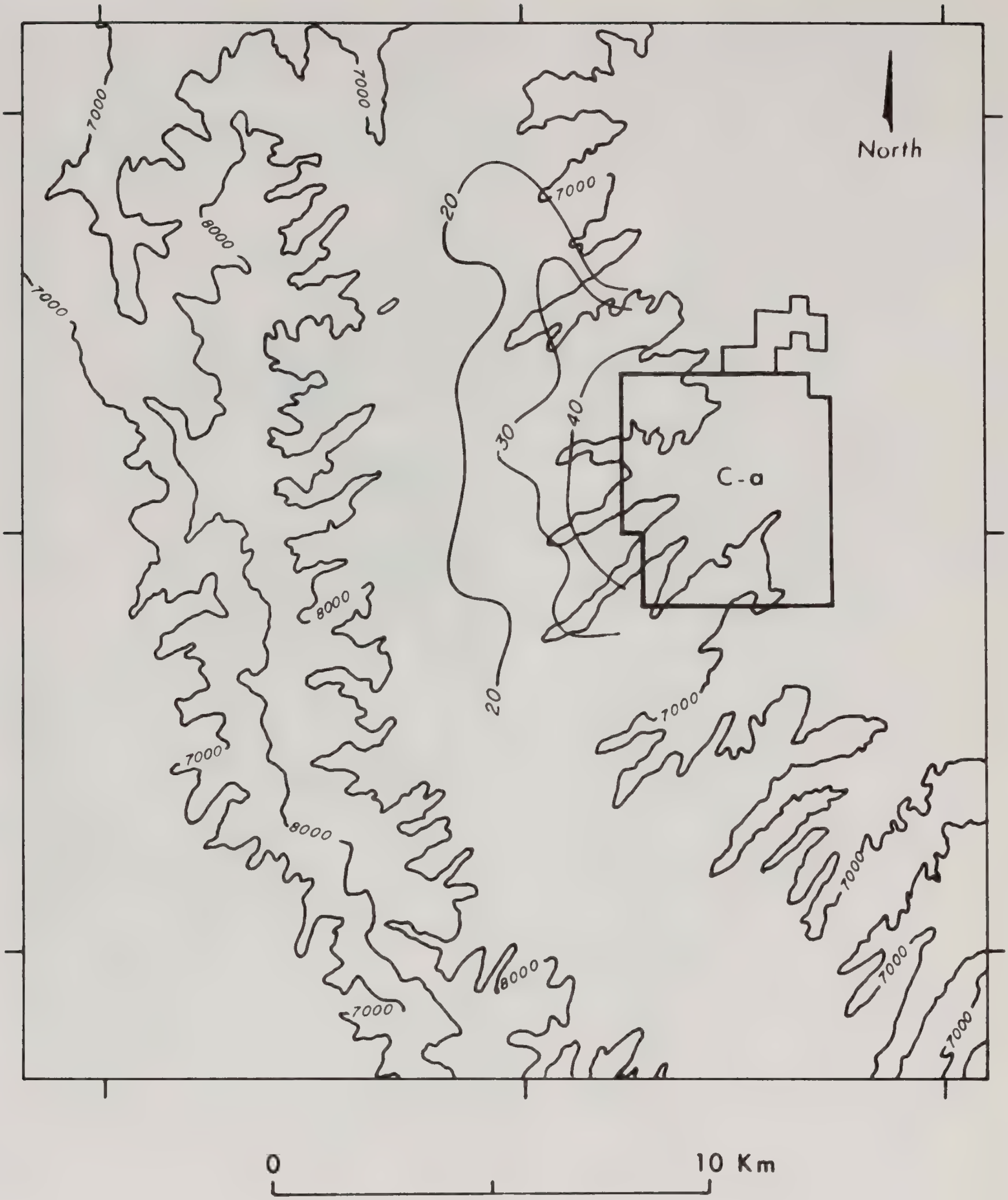



Figure 7-5-6
Maximum 3-Hour SO2 Concentrations (ug/m$^3$) as Calculated by Sequential Valley for C-a Sources Alone

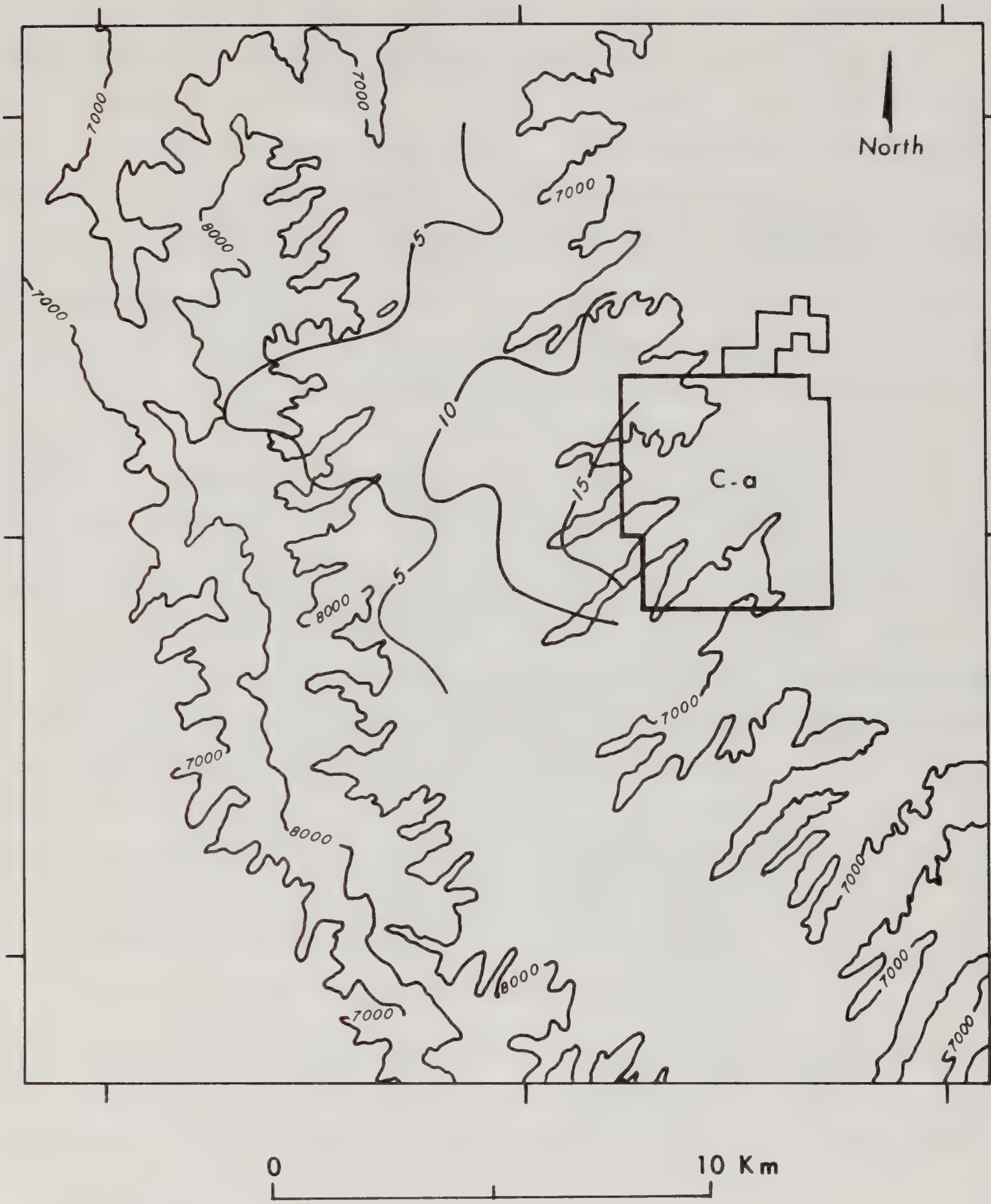



Figure 7-5-7
Maximum 24-Hour SO2 Concentrations (ug/m$^3$) as Calculated by Sequential Valley for C-a Sources Alone

In order to more accurately determine the air quality impacts on the Cathedral Bluffs area due to Tract C-a operations, the five highest periods of 3-hour $SO_2$ concentrations predicted at Cathedral Bluffs by the Sequential VALLEY modeling were examined in detail. A calculation suggested by fluid modeling studies, called the hill Froude number, predicts whether air parcels (or plumes) will preferentially flow directly onto high terrain, causing high air quality impacts (such as assumed in Sequential VALLEY), or will preferentially flow over the terrain with a greatly reduced impact. This hill Froude number is a measure of the vertical inertia of a horizontally advecting parcel of air encountering the high terrain in comparison to gravitational forces (which tend to prevent the parcel from rising).

The results of the hill Froude number calculation (presented in detail in the PSD application for the Lurgi Demonstration Project) demonstrate that the plumes from Tract C-a will tend to flow over Cathedral Bluffs in all of the worst case conditions. Consequently, a plume height correction factor of 0.35 under stable atmospheric conditions (found to be the worst case in the Sequential VALLEY modeling) was used in the more sophisticated MPSDM model. This correction factor limits the reduction of plume centerline height when passing over elevated terrain to 0.35 of the inital effective stack height (instead of the minimum plume height of 10 m assumed by the Sequential VALLEY model), thus accounting for the preferential flow of plumes over Cathedral Bluffs shown by the hill Froude number calculations. As a result, the MPSDM model results are probably be more reasonable and accurate than those of the the Sequential VALLEY model.

The MPSDM modeling was performed over a much wider area than the Sequential VALLEY modeling (Figure 7-5-3). The objectives of the MPSDM modeling differed from the Sequential VALLEY modeling in that not only were potential impacts on the high terrain immediately to the west of Tract C-a considered, but also the entire air shed within and surrounding the Piceance Creek Basin.

A summary of the results is shown in Table 7-5-16. All predicted concentrations are well below the Class II increment for $SO_2$. Annual-average concentrations of $SO_2$ were extremely low, and probably below detectability in all areas. The spatial distribution of the $SO_2$ emissions from Tract C-a

Table 7-5-16

SUMMARY OF MAXIMUM $SO_2$ CONCENTRATIONS IN CLASS II AREAS AS CALCULATED BY MPSDM

| | Highest $SO_2$ Concentration | | Second Highest $SO_2$ Concentration | | Class II PSD Increment |
|---|---|---|---|---|---|
| | Value ($\mu g/m^3$) | Receptor[a] | Value ($\mu g/m^3$) | Receptor[a] | ($\mu g/m^3$) |
| Tract C-a Source Alone | | | | | |
| 3-hour | 20.7 | 1 | 20.3 | 2 | 512 |
| 24-hour | 6.5 | 58 | 6.4 | 60 | 91 |
| Annual | 0.7 | 21 | 0.4 | 22 | 20 |
| All Sources | | | | | |
| 3-hour | 83.5 | 114 | 79.8 | 116 | 512 |
| 24-hour | 21.8 | 109 | 19.8 | 114 | 91 |
| Annual | 2.7 | 110 | 2.4 | 118 | 20 |

[a] Receptor sites are shown in Figure 7-5-3

alone for the three averaging periods are shown in Figures 7-5-8, 7-5-9, and 7-5-10. As previously described, the short-term maximum concentrations are shown as zones of influence, rather than isopleths.

When the $SO_2$ emissions for all permitted oil shale projects are included, the location of highest air quality impact changes significantly. The MPSDM modeling predicts that the highest concentrations occur to the southeast of Tract C-a, near the other oil shale developments. The isopleths and zones of influence indicate that the highest concentrations should occur between Tract C-b and the Union and Colony sources. This result appears to be reasonable, since the other projects have much higher production rates. The spatial distribution of $SO_2$ emissions from the combined sources is shown in Figures 7-5-11, 7-5-12, and 7-5-13.

The results of the MPSDM and Sequential VALLEY modeling show that the operation of the Lurgi Demonstration Project at Tract C-a will not result in violation of the $SO_2$ increment in the area.

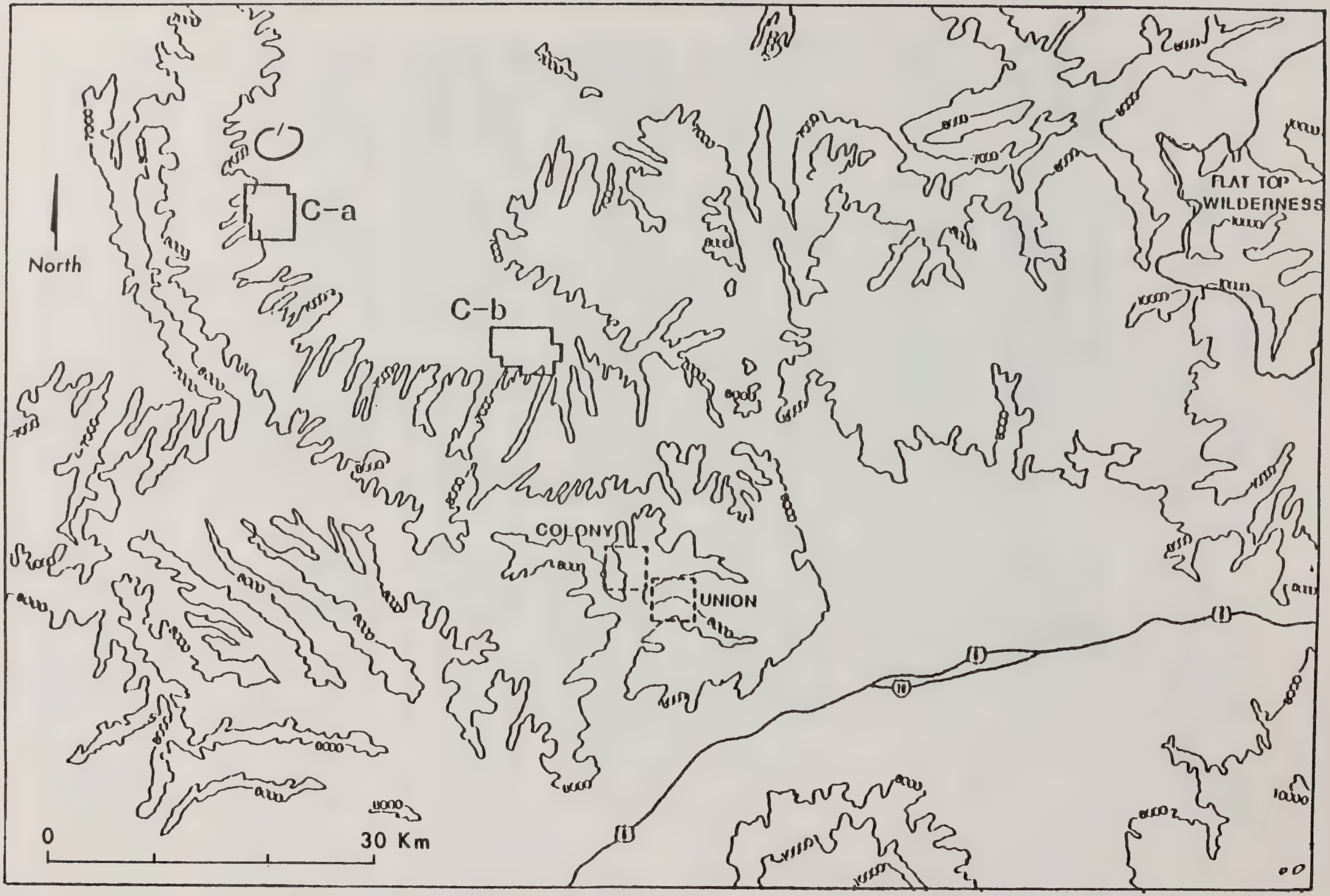



Figure 7-5-8
Annual-Average $SO_2$ Concentration (ug/m3) as Calculated by MPSDM for C-a Sources Only.

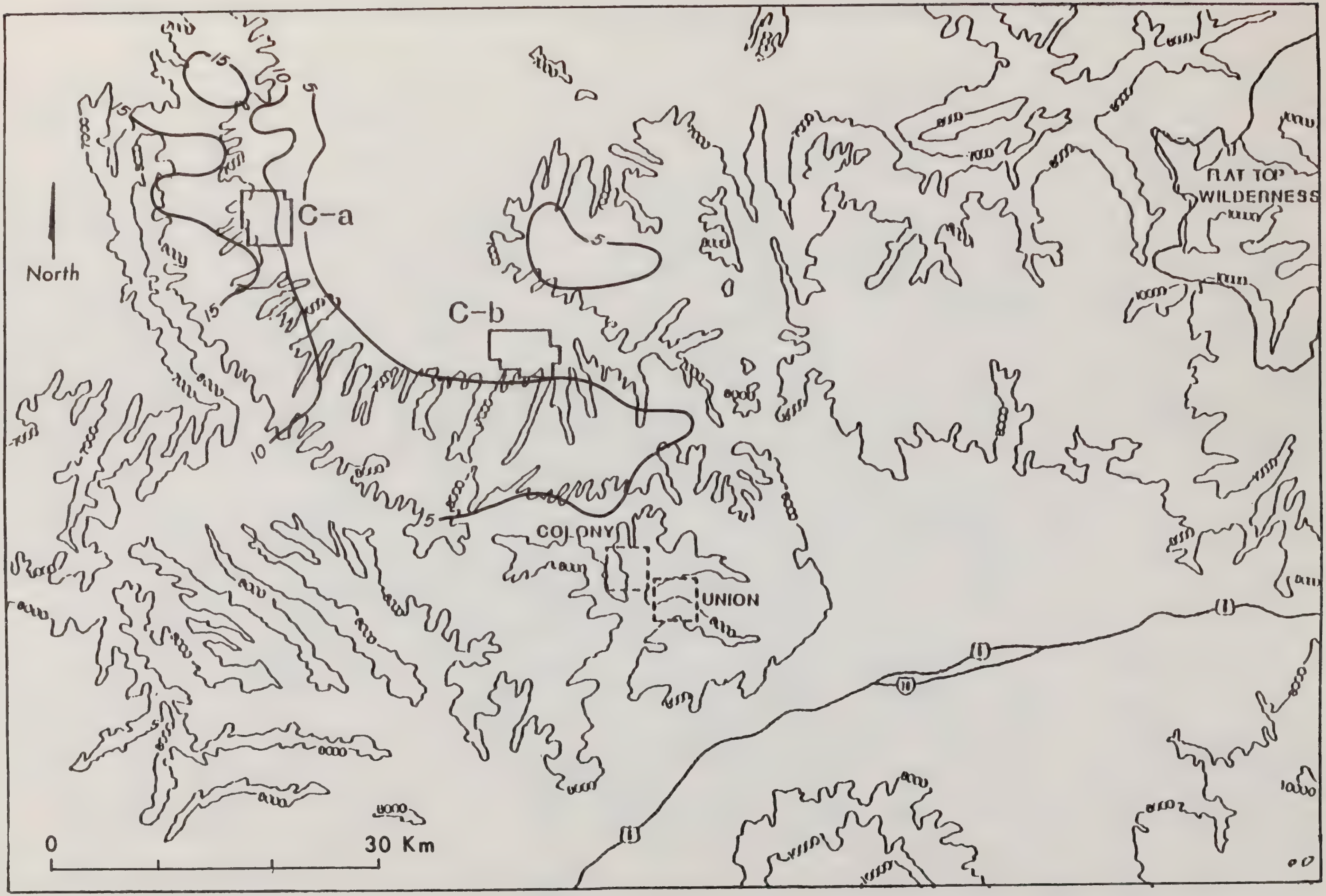



Figure 7-5-9
Maximum 3-Hour SO2 Concentrations (ug/m3) as Calculated by MPSDM for C-a Sources Alone.

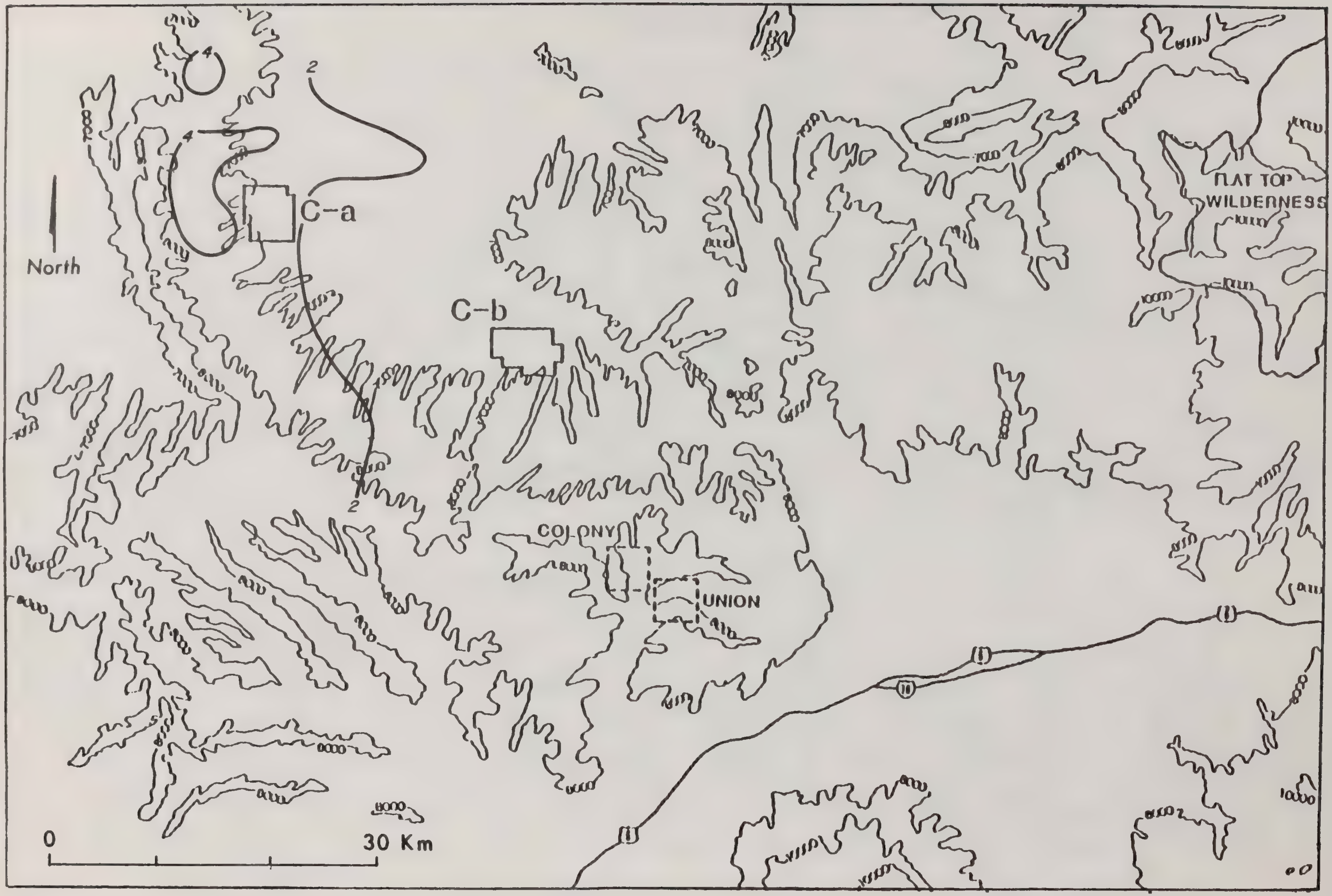



Figure 7-5-10
**Maximum 24-Hour $SO_2$ Concentrations (ug/m3) as Calculated by MPSDM for C-a Sources Alone.**

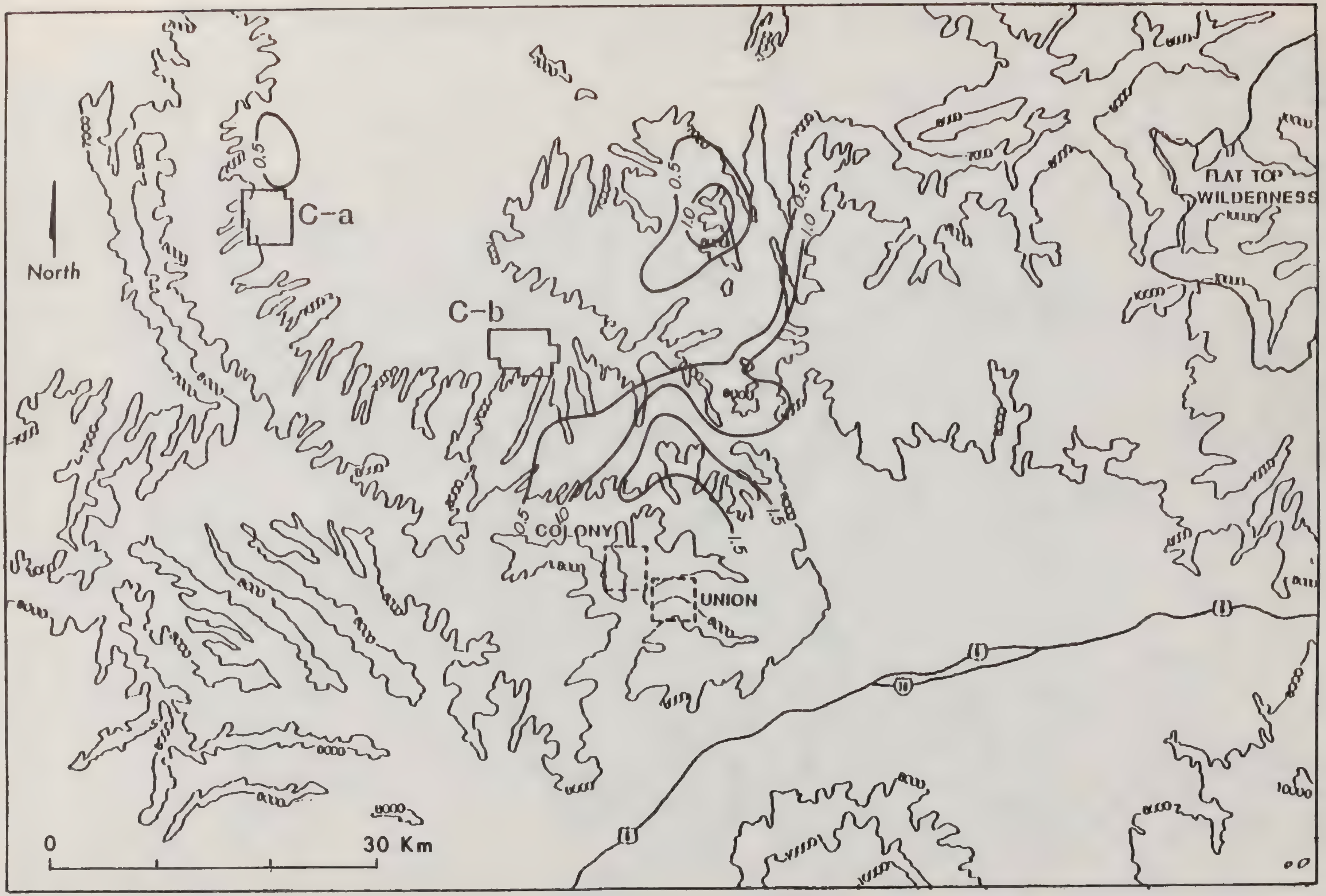



Figure 7-5-11
Annual-Average $SO_2$ Concentration (ug/m3) as Calculated by MPSPM for all Sources.

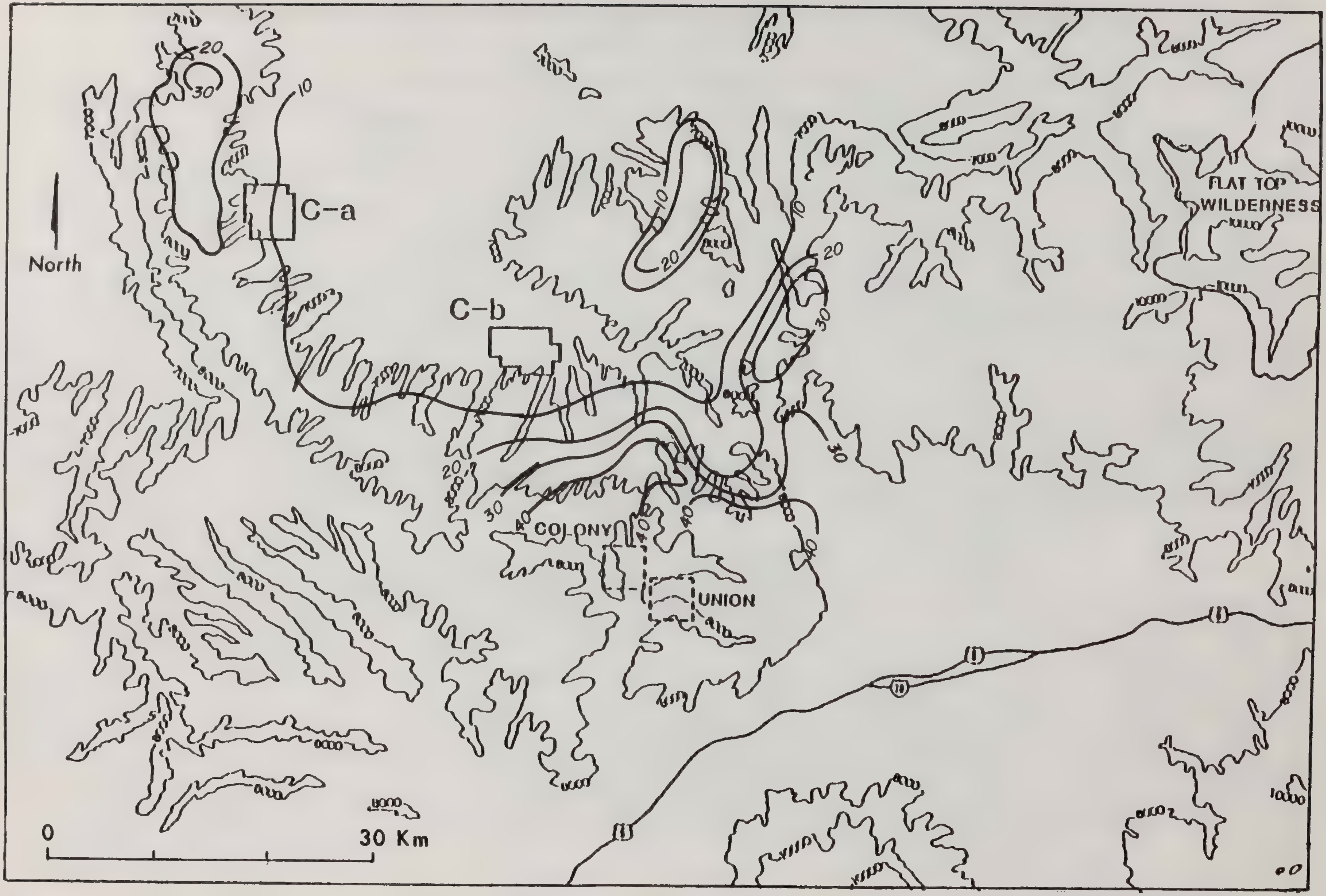



**Figure 7-5-12**
**Maximum 3-Hour Concentrations (ug/m3) as Calculated by MPSDM for all Sources.**

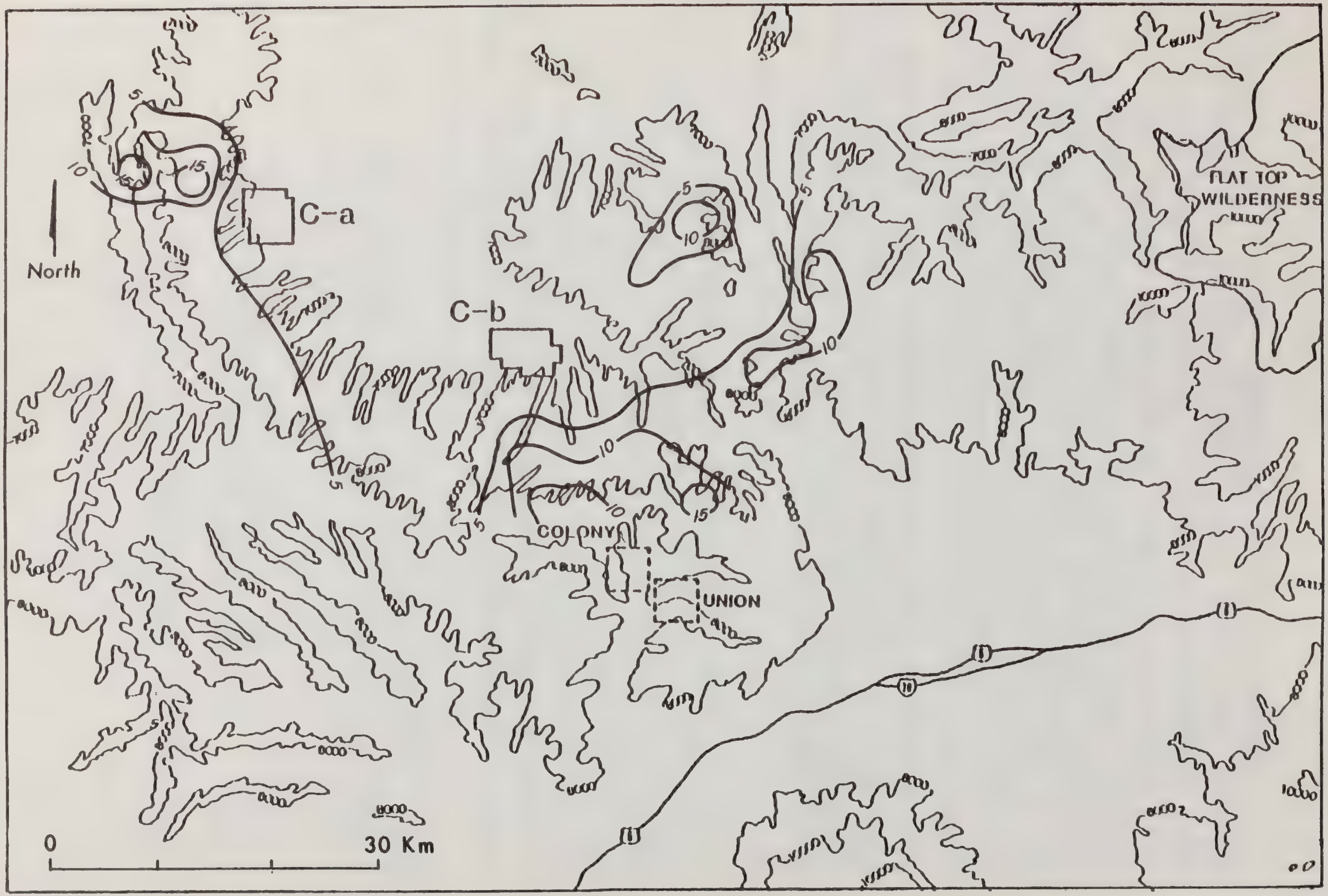



Figure 7-5-13
Maximum 24-Hour Concentrations (ug/m3) as Calculated by MPSDM for all Sources.

2. <u>Consumption of Class I $SO_2$ Increment</u> - The analysis of $SO_2$ concentrations in Class I areas was performed for the Flat Tops Wilderness area. Class I concentrations calculated by the MPSDM model are shown on Table 7-5-17 (Tract C-a sources alone and all sources combined). The predicted concentrations in all cases are below the Class I PSD increments. It is believed that the predicted concentrations in the Flat Tops Wilderness area are very conservative. The MPSDM model assumes that the wind will continue in a straight line for the entire distance between the sources and the Flat Tops Wilderness area. This is not representative of plume behavior in the canyons and river valleys of the western United States. In addition, the model does not take into account the wind direction variability during the time required to transport the plumes over the large distances involved. Thus, impacts are predicted over longer periods of time than would normally be expected, and the results tend to be overly conservative.

Table 7-5-17

SUMMARY OF MAXIMUM PREDICTED $SO_2$ CONCENTRATIONS IN THE FLAT TOPS WILDERNESS AREA

MPSDM RESULTS

| | Highest $SO_2$ Concentration | | Second Highest $SO_2$ Concentration | | Class I PSD Increments |
|---|---|---|---|---|---|
| | Value ($\mu g/m^3$) | Receptor[a] | Value ($\mu g/m^3$) | Receptor[a] | ($\mu g/m^3$) |
| Tract C-a Source Alone | | | | | |
| 3-hour | 1.9 | 124 | 1.8 | 122 | 25 |
| 24-hour | 0.3 | 128 | 0.3 | 124 | 5 |
| Annual | 0.01 | 121 | 0.01 | 124 | 2 |
| All Sources | | | | | |
| 3-hour | 15.6 | 124 | 14.6 | 125 | 25 |
| 24-hour | 2.6 | 127 | 2.5 | 128 | 5 |
| Annual | 0.4 | 121 | 0.3 | 124 | 2 |

[a] Receptor sites are shown in Figure 7-5-3

3. Consumption of Class II TSP Increments - The particulate emissions from the elevated stacks and the fugitive dust from the mining operations will both contribute to TSP concentrations. The ground-level nature of the fugitive dust emissions, combined with the larger overall emission rates as compared to stack sources, makes the mine emissions more significant than stack emissions for Class II area PSD increment consumption. An analysis of the fugitive dust emissions showed that peak emissions will occur in 1983 when Phase I processing and ore production and Phase II overburden removal is underway. Stack particulate will also be emitted during 1983.

Maximum particulate concentrations were analyzed using the ERT MINE model and the EPA model PTMTP. Fugitive dust emissions were divided into 25 individual sources for input into the MINE model, including point sources, area sources, and line sources. Maximum particulate emission rates from the Lurgi and MIS stacks were modeled with the PTMTP model.

Receptors were selected for the MINE modeling outside of the property boundary area for the Lurgi Demonstration Project (Figure 7-5-4). For those receptors and associated meteorological conditions where the highest TSP concentrations resulted from fugitive dust emissions, PTMTP runs were made with the same receptors and meteorological data to determine the total TSP concentration resulting from fugitive and stack emissions. The concentrations of TSP from the PTMTP runs were negligible compared to the TSP concentrations from fugitive sources.

The highest and second highest TSP concentrations outside the property boundaries are shown in Table 7-5-18. These concentrations are well below the allowable PSD increments.

TABLE 7-5-18

SUMMARY OF MAXIMUM CALCULATED TSP CONCENTRATIONS IN CLASS II AREAS OUTSIDE THE PROPERTY BOUNDARY

| Emission Scenario | Highest TSP[1] Concentration ($\mu g/m^3$) | Second Highest TSP Concentration ($\mu g/m^3$) | Class II TSP Increment, ($\mu g/m^3$) |
|---|---|---|---|
| 1983: | | | |
| 24-hour | 15.2 | 14.4 | 37 |
| Annual | 3.5 | 2.7 | 19 |

[1] See Figures 7-5-14 amd 7-5-15 for location of maximum values.

The predicted maximum 24-hour average concentration in 1983 occurred at the northern tract boundary directly north of the open pit. Figure 7-5-14 shows the location of the peak TSP concentration and the zones of influence for the maximum 24-hour TSP concentrations in 1983. The maximum values occurred during stable flows with winds from the south. Figure 7-5-15 shows the isopleths of annual-average concentration for 1983. Peak annual average concentrations are expected to occur on the eastern boundary of the tract. This is consistent with the predominant winds (west-southwest) at Tract C-a.

The short-term and annual concentrations during 1981, 1982 and 1984 are expected to be lower in magnitude than those for 1983, due to the lower emission rates during these periods.

There could be some additional contributions to the TSP concentrations in the project area from the other oil shale developments. These would not, how ever, impact the project area during the stable flow conditions which are expected to produce the maximum concentrations from the Lurgi Demonstration Project mining sources. The results of the elevated stack modeling for $SO_2$ showed that impact of the other sources (C-b, Colony, Union) in the immediate area around Tract C-a is expected to be minimal. Thus, it is believed that the impacts on the project area of the TSP emissions from these sources can be ignored.

The conclusion is, then, that TSP concentrations from all operational activities will not exceed the Class II increments at or beyond the property boundary as a result of the proposed project.

4. <u>Consumption of Class I TSP Increments</u> - The impact of the fugitive dust emissions from the mining operations was not considered in the analysis of impacts on the Flat Tops Wilderness area, because preliminary calculations showed the amount of particulate matter from fugitive dust that would remain suspended after traveling 80 kilometers to the wilderness area was negligible. Thus, only particulate emission from elevated sources were considered in predicting the TSP concentrations in Class I areas.

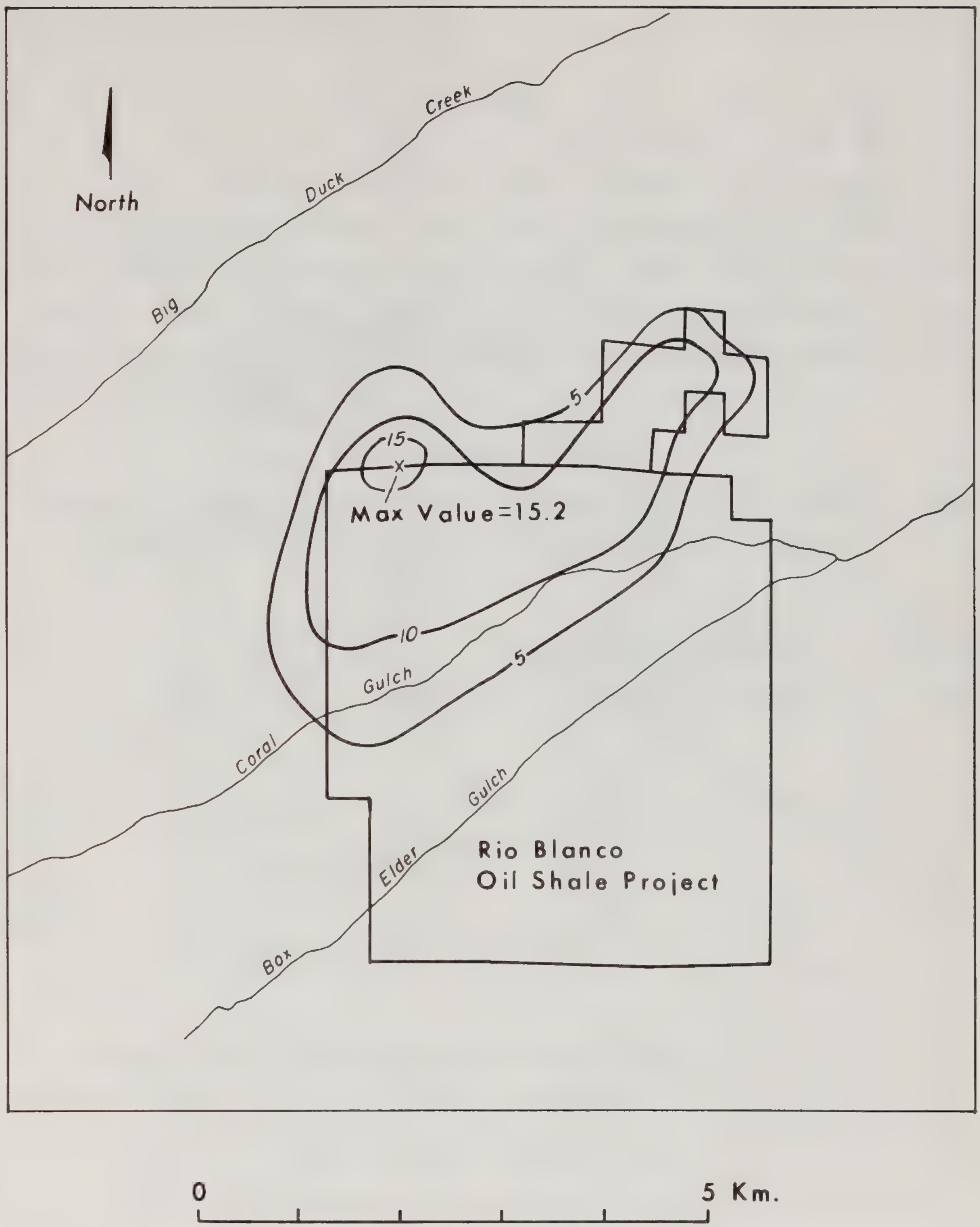



Figure 7-5-14
Maximum 24-Hour TSP Concentrations (ug/m³) as Calculated by Mine for Emissions During 1983

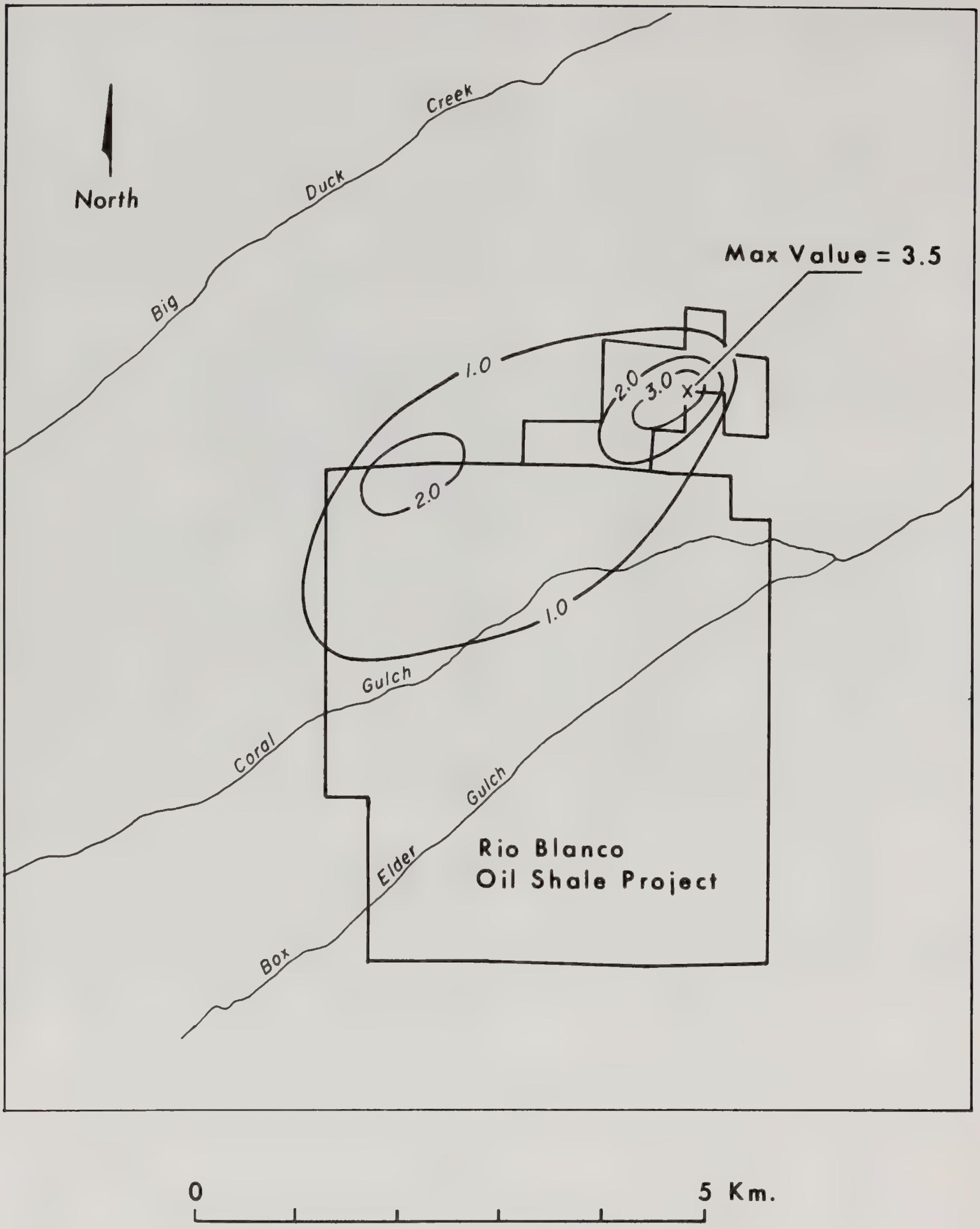



Figure 7-5-15
Annual-Averages TSP Concentration (ug/m3) as Calculated by Mine for Emissions During 1983

Instead of conducting a specific modeling study of particulate emissions from the elevated point sources, the results of the $SO_2$ modeling study were scaled by the ratio of the total particulate matter emission rate to the total $SO_2$ emission rate in order to estimate TSP concentrations in the Flat Tops Wilderness area. For the C-a sources alone, this scaling factor was 0.48. When all sources were evaluated, the scaling factor was calculated to be 0.63. The concentrations resulting from scaling the values of Table 7-5-17 are shown in Table 7-5-19. Table 7-5-19 shows that the project is not expected to result in any violation of the Class I TSP PSD increments in the Flat Tops Wilderness area.

Table 7-5-19

SUMMARY OF MAXIMUM CALCULATED TSP CONCENTRATIONS IN THE FLAT TOPS WILDERNESS AREA AS OBTAINED BY SCALING MPSDM $SO_2$ RESULTS

| | Highest TSP Concentration | | Second Highest TSP Concentration | | Class I PSD Increment |
|---|---|---|---|---|---|
| | Value ($\mu g/m^3$) | Receptor | Value ($\mu g/m^3$) | Receptor | ($\mu g/m^3$) |
| Tract C-a Sources Alone | | | | | |
| 24-hour | 0.1 | 128 | 0.1 | 124 | 10 |
| Annual | negligible | 121 | negligible | 124 | 5 |
| All Sources | | | | | |
| 24-hour | 1.6 | 127 | 1.6 | 128 | 10 |
| Annual | 0.3 | 121 | 0.2 | 124 | 5 |

5. Compliance With State and Federal Ambient Standards - Compliance with Colorado and National Ambient Air Quality Standards (CAAQS and NAAQS, respectively) is determined by adding the existing background concentrations to the additional pollutant loadings resulting from the various permitted sources in the Piceance Basin area. The following discussions address the determination of background air quality at Tract C-a, and the predicted compliance with the CAAQS and NAAQS.

RBOSC has been gathering air quality data in the vicinity of Tract C-a since February 1975. The objective of this monitoring effort has been to determine background concentrations prior to major development on Tract C-a. Air quality parameters measured continuously include sulfur dioxide ($SO_2$), oxides of nitrogen ($NO_x$), nitric oxide (NO), carbon monoxide (CO), and ozone ($O_3$).

Average annual concentrations at Tract C-a have varied from year to year and location to location. The median of all these reported annual averages can be taken, however, as a reasonable approximation of background concentration for each air quality parameter. Median values, by parameter, are as follows:

| | | | | | |
|---|---|---|---|---|---|
| $SO_2$ | - | 22 $\mu g/m^3$ | $O_3$ | - | 62 $\mu g/m^3$ |
| $NO_x$ | - | 9 $\mu g/m^3$ | CO | - | 520 $\mu g/m^3$ |
| TSP | - | 13 $\mu g/m^3$ | | | |

The proposed project must demonstrate compliance with all ambient air quality standards in effect for the project area. Table 7-5-20 shows the National Ambient Air Quality Standard (NAAQS) and Colorado Ambient Air Quality Standards (CAAQS) applicable to the Tract C-a sources.

TABLE 7-5-20

AMBIENT AIR QUALITY STANDARDS ($\mu g/m^3$)

| Pollutant | Averaging Time | Federal NAAQS | CAAQS |
|---|---|---|---|
| Sulfur dioxide | Annual | 80 | N/A |
| | 24-hour | 365 | N/A |
| | 3-hour | 1300[1] | N/A |
| Total Suspended Particulates | Annual[2] | 75(60[1]) | 75(60[1]) |
| | 24-hour | 260(150[1]) | 260(150[1]) |
| Nitrogen Dioxide | Annual | 100 | 100 |
| Carbon Monoxide | 1-hour | 40,000 | 40,000 |
| | 8-hour | 10,000 | 10,000 |
| Photochemical Oxidants | 1-hour | 235 | 235 |

[1] Denotes secondary standard

[2] Geometric mean

Although construction-related emissions can be excluded from the fugitive emission inventory when determining PSD increment consumption, these emissions must be included when comparing Federal and State air quality standards to ambient TSP concentrations. For purposes of PSD increment consumption, 1983 activities generated the highest emission rates; however, when construction-related emissions are included, 1981 activities produced the highest short-term emissions and 1982 activities generated the highest annual emissions. Thus, annual and 24-hour ambient TSP concentrations were estimated by adding the MINE model predictions for 1982 and 1981 respectively, to the background TSP concentrations to determine compliance with NAAQS and CAAQS.

For stack emissions, air quality modeling has been performed only for $SO_2$ emissions from the various stacks. By scaling the $SO_2$ concentrations using the emission rates from the various sources (Table 7-5-21), the maximum concentrations of the other pollutants can be estimated.

TABLE 7-5-21
SCALED CONCENTRATIONS FOR POLLUTANTS
NOT SPECIFICALLY MODELED

| Pollutant[1] | $SO_2$ Concentration Scaled | Scaling Factor | Scaled Concentration |
|---|---|---|---|
| C-a Sources Alone: | | | |
| Nitrogen Dioxide | 0.7 (annual) | 3.49 | 2.4 (annual) |
| Carbon Monoxide[2] | 20.7 (3-hour) | 0.54 | 11.2 (1-hour and 8-hour) |
| All Sources | | | |
| Nitrogen Dioxide | 2.7 (annual) | 4.84 | 13.1 (annual) |
| Carbon Monoxide[2] | 83.7 (3-hour) | 7.31 | 611.8 (1-hour and 8-hour) |

1 No analysis is presented for oxidant since there is no acceptable method for scaling hydrocarbon emissions to determine oxidant concentration.

2 One value was used here for both 8-hour and 1-hour carbon monoxide concentrations. The value scaled was the 3-hour $SO_2$ model prediction.

The model results were then added to the background values listed above. The results are shown in Table 7-5-22 and indicate that no ambient air quality standards are predicted to be exceeded by the proposed project.

TABLE 7-5-22

EXPECTED TOTAL POLLUTANT CONCENTRATIONS ($\mu g/m^3$)

| Pollutant | Model Prediction (all sources) | Background | Total |
|---|---|---|---|
| Sulfur dioxide | | | |
| 3-hour | 84 | 22 | 106 |
| 24-hour | 22 | 22 | 44 |
| Annual | 3 | 22 | 25 |
| Total Suspended Particulates | | | |
| 24-hour | 97.7 | 13 | 110.7 |
| Annual | 18.5 | 13 | 31.5 |
| Nitrogen Dioxide | | | |
| Annual | 13 | 9 | 22 |
| Carbon Monoxide | | | |
| 1-hour | 612 | 520 | 1,132 |
| 8-hour | 612 | 520 | 1,132 |
| Photochemical Oxidant ($O_3$) | | | |
| 1-hour | 1/ | 62 | 1/ |

1/ No analysis is presented for photochemical oxidant; however, the very low level of hydrocarbon emissions from the proposed project makes it very unlikely that any significant impact or oxidant concentration would occur.

6. Other Air Quality Considerations

a. Visibility - The impacts of air pollutant emissions from the proposed Lurgi Demonstration Project on visibility, were also addressed. Draft EPA guidelines for estimating visibility impairment (EPA 1980) were used to project potential visibility impacts for the Flat Tops Wilderness Area, the nearest Class I area. The screening procedure outlined in the EPA document issued May 30, 1980 was used to estimate visibility impairment. EPA has developed the five critical parameters listed below for evaluating visibility impacts to Class I areas:

- The minimum distance from the project to the Class I area
- The geographic location of both
- The particulate emission rate
- The $SO_2$ emissions rate
- The emission rate of nitrogen oxides ($NO_x$).

A numerical system has been developed by EPA for evaluating visibility impacts. If the absolute value for each parameter is less than 0.1, the project can be assumed to have little or no impact on visibility.

For the visibility assessment, determination of the numerical rating for the visibility parameters yielded values of 0.01 or less, which is considerably lower than the 0.1 criterion discussed above. Thus, no visibility impacts at Flat Tops Wilderness Area are anticipated. Details of the visibility calculation are included in the PSD application for the Lurgi Demonstration Project.

The particulate concentrations resulting from the mining operations may result in some localized dust plumes in the immediate area surrounding the mine. These should only be visible occasionally and should not result in any regional visibility degradation.

b. Soils and Vegetation - Impacts of air pollutants to soils and vegetation were estimated from literature data on the effects of TSP, $NO_x$ and $SO_2$ on soils and vegetation. Based on the limited data available, no air quality related impacts should occur to trees, grasses, shrubs or forbs at Tract C-a or at the Flat Tops Wilderness Area.

A more detailed discussion of the impacts of air pollutants on soils and vegetation is included in Section 7 of the PSD permit application.

7. Air Emissions Due to Secondary Growth - The increased population that will result from the Lurgi Demonstration Project will contribute to the emissions of various air pollutants in the general area. The project-related population increase fluctuates throughout the life of the project, but reaches a maximum value in 1983 of approximately 970 persons.

Two sources of emission will result from this projected population increase:

- Vehicular traffic
- Space heating

The emissions from vehicular traffic have been calculated assuming 2.0 vehicles per family, 12,000 miles per vehicle-year and emission factors taken from the EPA document AP-42 (U.S. EPA 1977). The emissions from space heating were calculated assuming each family to be a residential natural gas customer and a value of 126.5 x $10^6$ Btu/yr. of natural gas purchase for each customer (U.S. Department of Commerce, 1978). This value represents an average gas consumption for Colorado. Emissions were then calculated using emission factors from the EPA document AP-42 (U.S. EPA, 1977).

The ambient impacts from these emissions were calculated with a simple box model. The emissions were assumed to enter uniformly in a vertical cross-section of a box 2 kilometers wide (roughly intended to simulate the size of Rifle, Colorado) and 500 meters high (a conservatively low value of the mixing depth).

Finally, the emissions were assumed to be dispersed by a 3 meter per second wind (a conservatively low value). Resultant concentrations are shown in Table 7-5-23. All values are extremely low and well below the level of detectability of most monitoring equipment.

TABLE 7-5-23

CALCULATED IMPACTS FROM SECONDARY GROWTH

| Pollutant | Average Concentration ($\mu g/m^2$) |
|---|---|
| Sulfur Dioxide | 0.01 |
| Oxides of Nitrogen | 0.09 |
| Total Suspended Particulates | 0.05 |
| Carbon Monoxide | 0.24 |
| Hydrocarbons | 0.07 |

8. Good Engineering Practice (GEP) - Section 123 of the Clean Air Act Amendments of 1977 addresses GEP stack height considerations. EPA draft guidelines (EPA 1980) provide a formula to calculate the maximum creditable stack height (GEP) which a source may use in calculating the air quality impact. The GEP formulation is as follows:

$H_G = H + 1.5\ L$

$H_G$ = GEP stack height

H = Height of the structure or nearby structure

L = Lesser dimension (height or width) of the structure of nearby structure.

For calculation purposes, the Lurgi retort was assumed to be 273 ft. tall and 35 ft. wide at the top. Based on the formula, GEP stack height is 325 ft. Since the Lurgi retort stack will be 300 feet tall, the stack design conforms to GEP guidelines.

Excessive concentrations of air pollutants near the retort due to aerodynamic downwash should not be a problem, because the Lurgi structure will not be enclosed above the 100 ft. level. In addition, the retort structure is very tall and narrow, and adjacent buildings are less than 100 ft. tall.

The other major stationary emission source for the Lurgi Demonstration Project will be the incinerator and $SO_2$ removal system. The stack for this source will not be enclosed and will be 310 ft. tall. Hence, no significant downwash or wake problems due to the proximity of the Lurgi retort structure are anticipated for the reasons delineated above.

9. De Minimis Pollutants - Little data are available presently on the concentration of the de minimis pollutants in the emissions from the Lurgi surface retort. Recently Lurgi-Frankfurt conducted pilot plants tests using shale from Tract C-b. RBOSC requested that flue emissions from this test run be analyzed for the following de minimis pollutants: lead, asbestos, mercury, beryllium, and fluorides. Unfortunately, Lurgi's laboratory in Frankfurt does not have the capability to conduct analyses for these pollutants. Lurgi is planning to conduct another pilot scale test in

February or March of 1981, using Tract C-b shale, and is planning to subcontract the laboratory analysis in order to determine the concentrations of the de minimis pollutants. These data will be forwarded to EPA and OSO immediately after receipt by RBOSC.

Based on existing data, RBOSC does not anticipate that any of the de minimis values will be exceeded. Because of the nature of the retorting process and the raw material (oil shale), no emissions of vinyl chloride, asbestos, or sulfuric acid mist are anticipated. Emissions of reduced sulfur species should be minimal due to the excess oxygen used in the combustion process and the natural sulfur scrubbing characteristics of the oxides produced during retorting.

The concentration of fluorides in Piceance Basin oil shale is generally high. Average concentration reported by the USGS for raw shale from Tract C-a was 1290 ppm. Samples of oil shale retorted in the Fischer assay show, however, that there is no significant loss of fluoride from the solid fraction during retorting because most of the fluoride in oil shale is inorganically bound (Saether et al 1980). Comparison of fluoride concentrations in fresh and processed shale from Tract C-a indicated that the concentration in processed shale is over 95% of that in the fresh shale.

Concentrations of mercury, beryllium and lead in oil shale are generally quite low. USGS reported that the average concentration of mercury for samples of Tract C-a oil shale was 0.14 ppm. Average lead concentrations in oil shale are usually from 20 to 30 ppm and beryllium concentrations of 1.5 to 2 ppm have been reported. RBOSC data indicate that there is no significant loss of mercury during retorting. Although similar data are not available for beryllium and lead, it is anticipated that these metals will also be retained in the solid phase and emissions will be substantially below the de minimis levels.

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# Section 7

# ENVIRONMENTAL PROTECTION, HEALTH and SAFETY

## Chapter 6

## WATER MANAGEMENT and QUALITY CONTROL

The proposed RBOSC surface mine and Lurgi demonstration plant will create several interrelated operational systems on sites such as the open pit mine, the Lurgi processing facility and the processed shale disposal pile. These systems will create water sources and water needs at various times and locations on the project site. To provide for efficient operation of the project, the following water management plan has been designed to insure that adequate water supplies of suitable quality will be available to fill project needs during the construction, operation and abandonment phases. The management scheme selects the source for each water need so that an efficient use of all water on site will be obtained. The same plan also provides for adequate disposal systems that comply with all pertinent regulations for excess water. To accomplish this end, the project operation has been broken down into four major systems and a miscellaneous group of closed systems. A closed system is one in which all water flows present are generated and discharged as part of that same system (except for water supplying such consumptive uses as dust control or reclamation irrigation). For each identified major system, generated water sources, water needs, discharges and losses have been identified. Design flows and demands have been defined and water balances for normal system flows and requirements have been prepared. The overall water flow diagrams with the design and normal flow values for the project construction, operation and abandonment phases are presented in Figures 7-6-1, 7-6-2 and 7-6-3 respectively. Figure 7-6-4 shows the ponds and lagoons required for water management.

## 6.1 WATER SUPPLY SYSTEM

The initial step for water management is to provide an adequate and dependable water source that can be used at varying rates to supply varying project needs. For this purpose water will be supplied from the Upper Aquifer at a design pumping capacity of 973,200 GPD. This water will be obtained from wells or mine seepage.

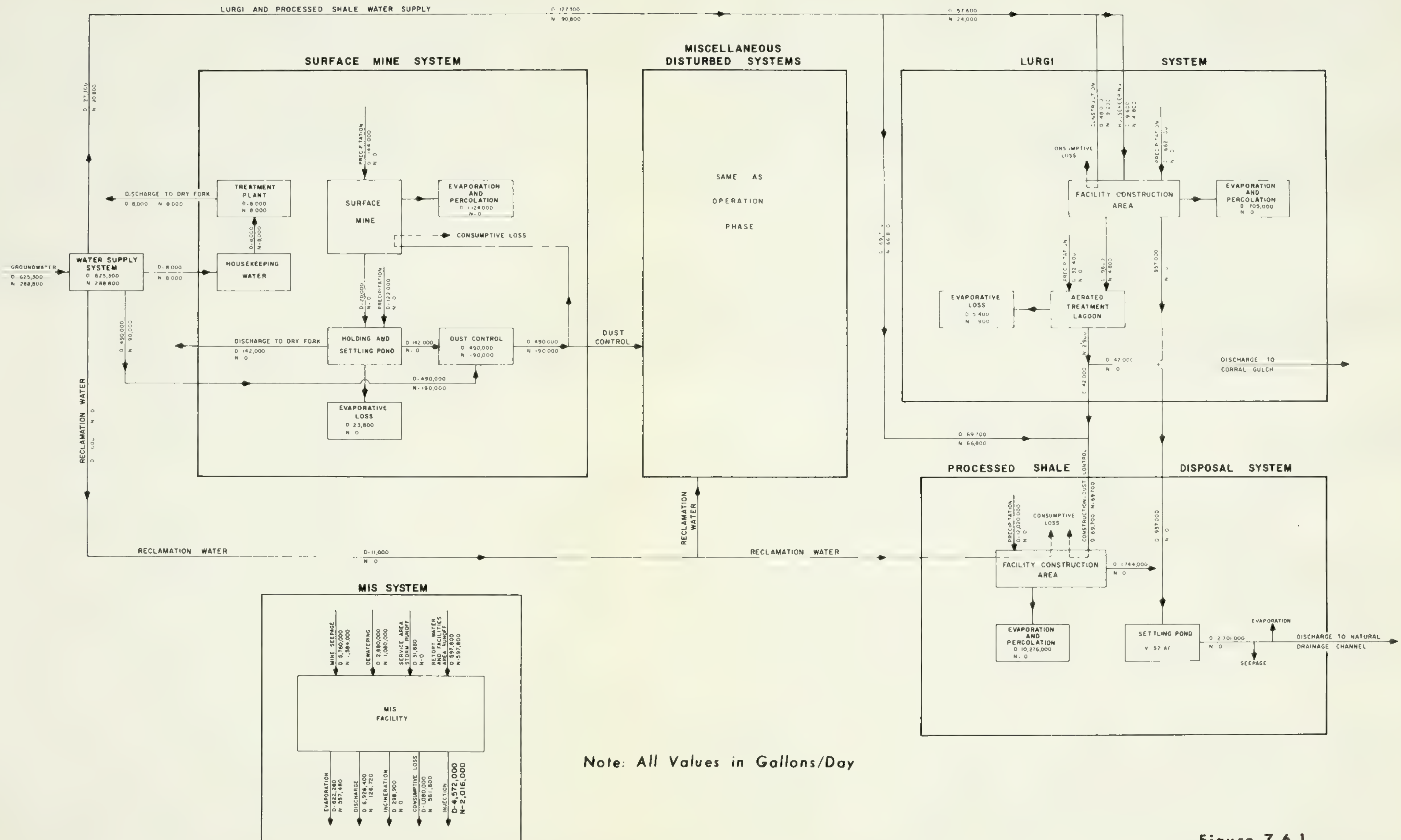
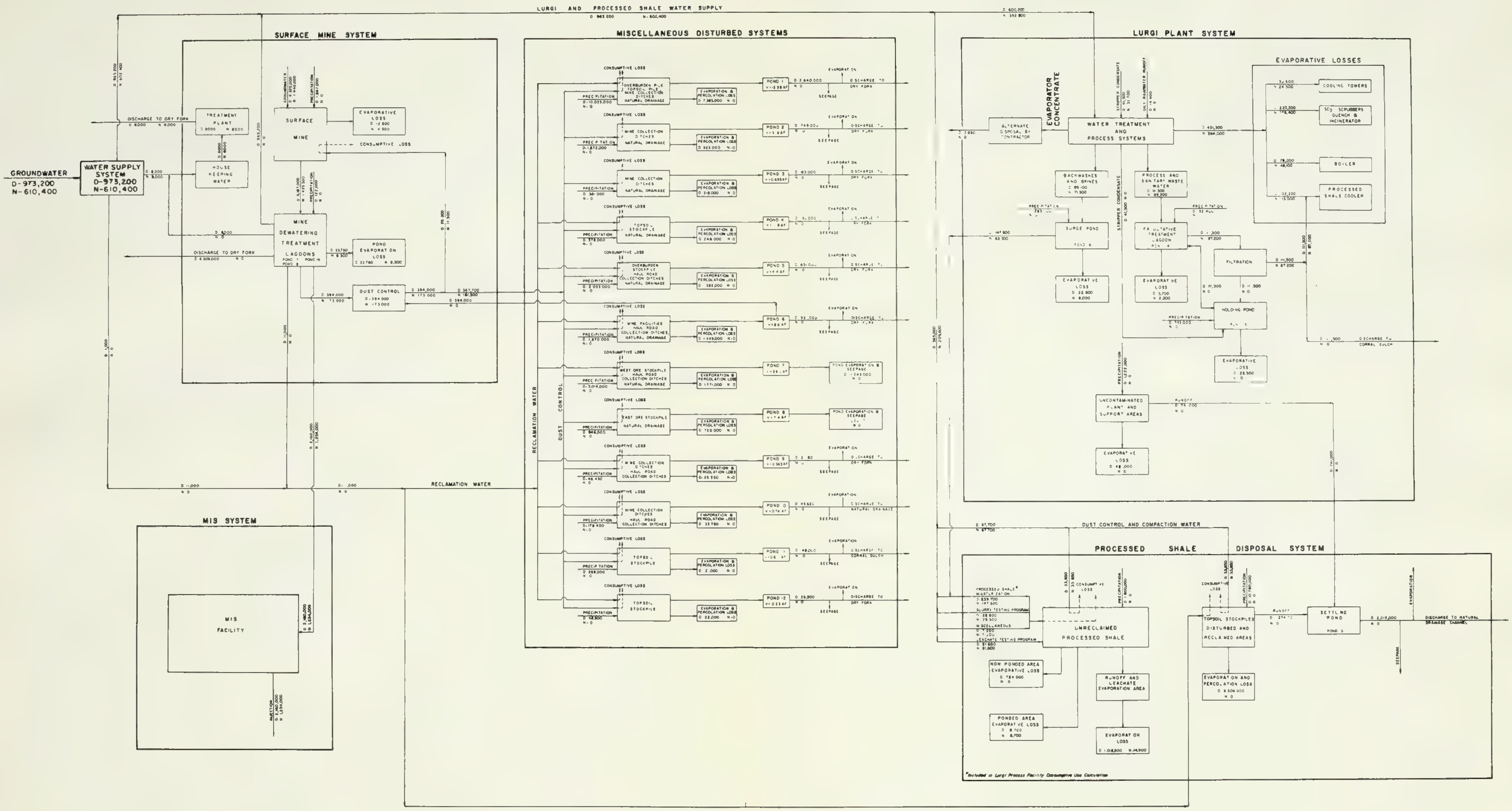



**Figure 7-6-1**
**Water Flow Diagram**
**Construction Phase**




*Note: All Values in Gallons/Day*

**Figure 7-6-2**
**Operational Phase - Water Flow Diagram**

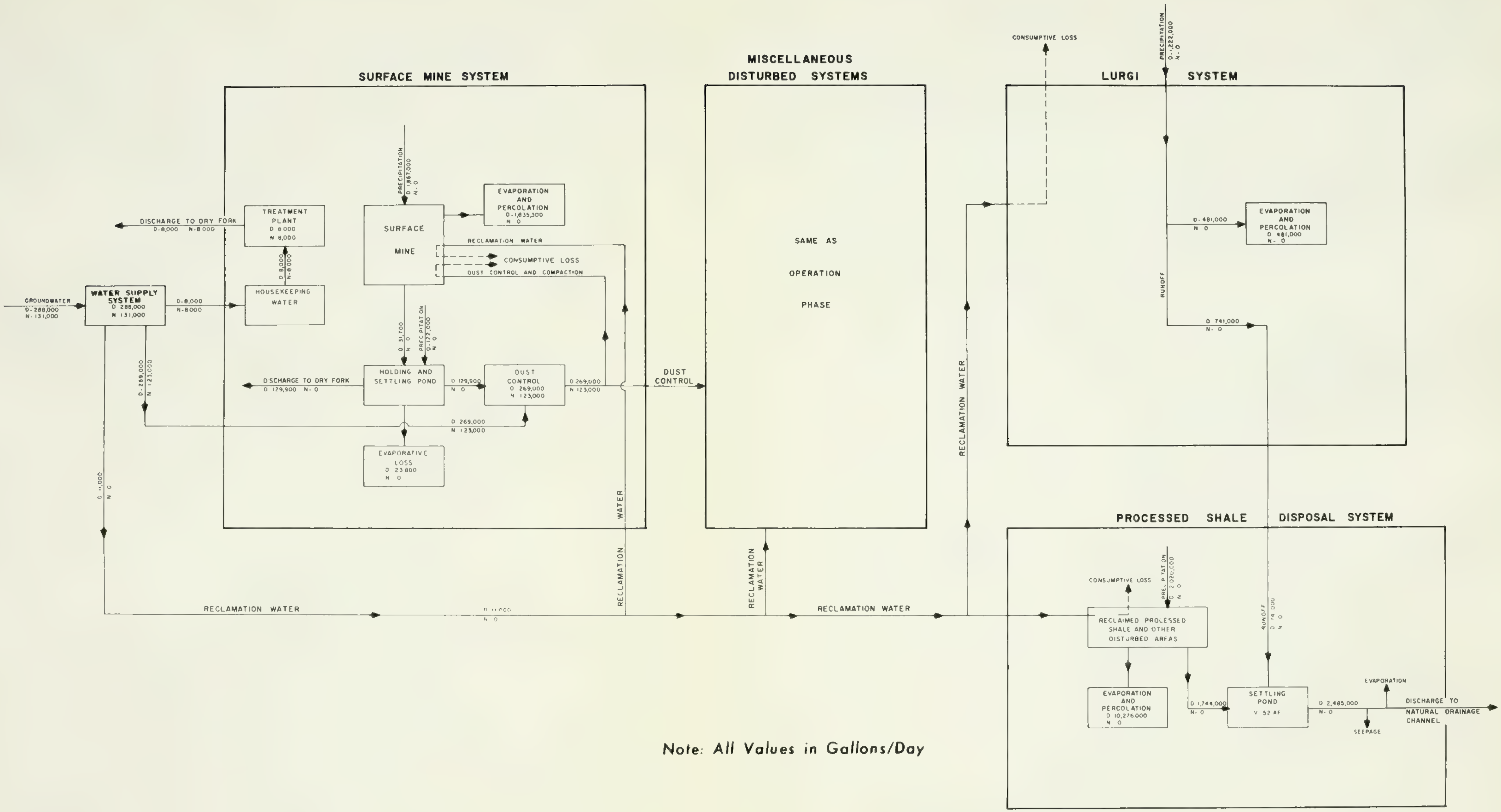



**Figure 7-6-3**
**Abandonment Phase Water Flow Diagram**

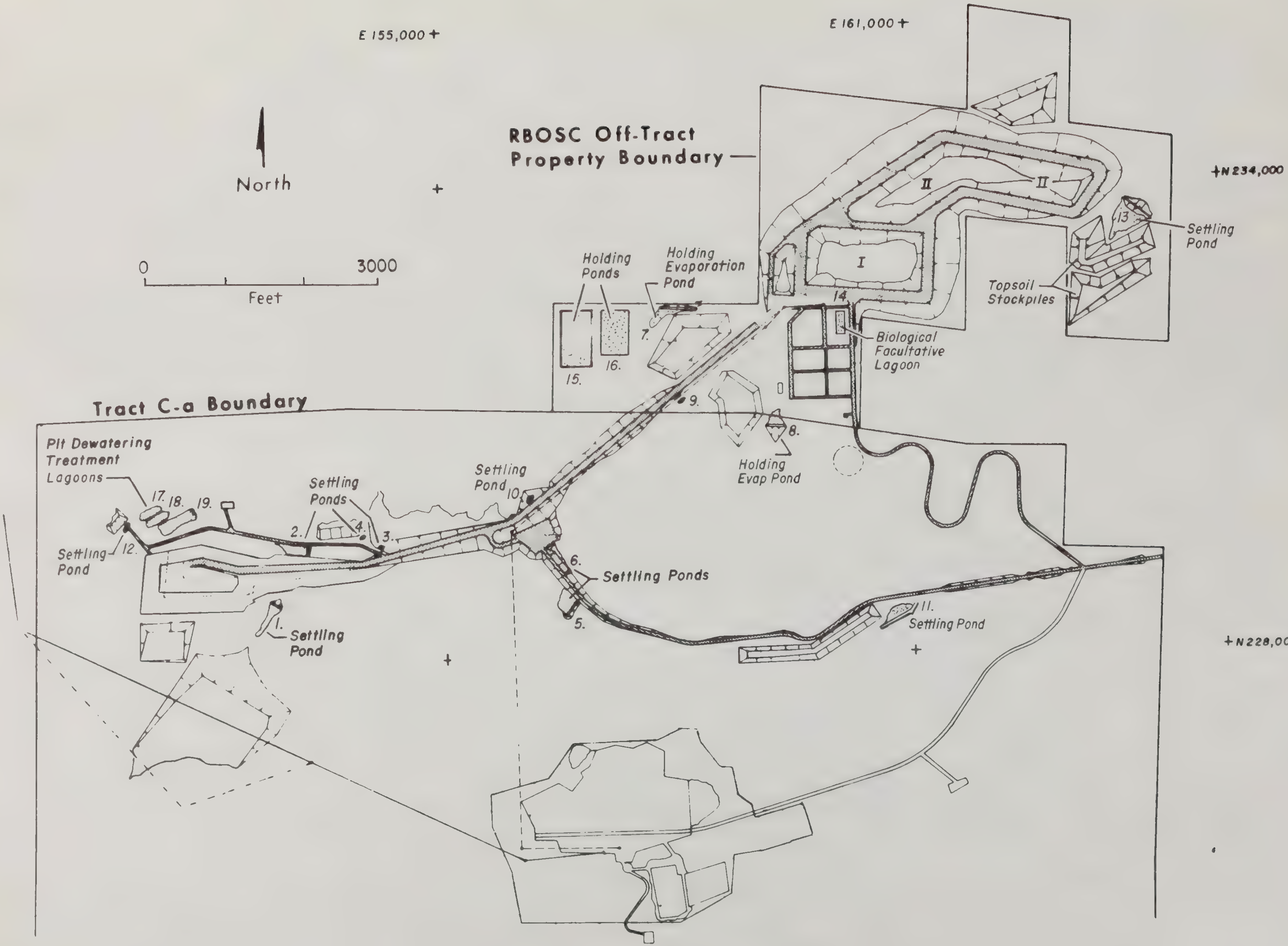



Figure 7-6-4
Pond Location Plot Plan

During the construction phase of the project, the water supply will have the capability to provide water for all needs including housekeeping and construction water for the Lurgi processing plant, the processed shale disposal site and the surface mine, and irrigation water for the reclamation of topsoil piles and haul road areas. This will require a normal flow of 289,000 GPD. During the project operation phase, the water supply will provide all water for the normal operation of the Lurgi processing plant and the processed shale disposal site, and housekeeping water for the surface mine. In addition, the water supply system will have the operational capacity to supply water for reclamation irrigation, and for storage in the mine system holding pond when water in that pond falls below a critical volume. Expected normal flow rates from the water supply system will be 610,000 GPD. The system will also provide all water for reclamation and potable water supplies during site abandoment, a normal daily requirement of 131,000 gallons. Figures 7-6-5, 7-6-6 and 7-6-7 respectively illustrate the system water balance for normal flows during the various project phases.

## 6.2 MINE SYSTEM

The surface oil shale mine will create a major water source at the project site. As the excavation of the surface mine progresses the upper aquifer will be penetrated, creating a considerable flow of water into the mine for several years. Flow into the mine will vary with the depth of excavation and number of water-bearing layers penetrated within the aquifer, possibly beginning with perched water in the overburden and continuing through the A groove and the B groove associated water-bearing zones. Additional water will also be periodically input into the mine area by precipitation. The removal of all water will be necessary to facilitate efficient mining. This will create a flow which, along with water from wells, will provide all of the make up water required for the operation phase. Expected normal flows from the combined sources over the life of the project are presented in Figure 7-6-8.

The mine system will also require water during the construction, operation and abandonment phases for such purposes as dust control, reclamation and

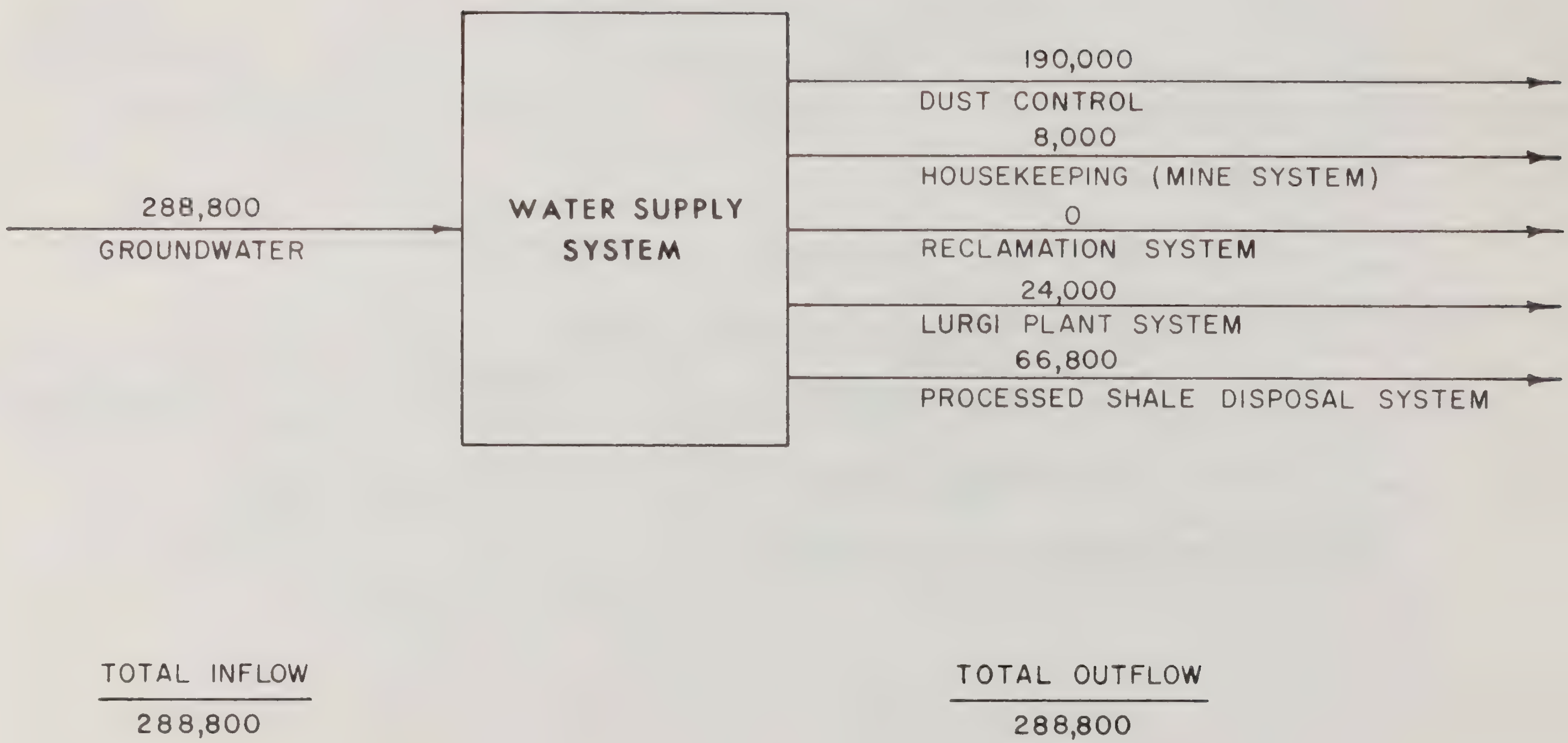



**Figure 7-6-5**
**Water Supply System Water Balance - Construction Phase**

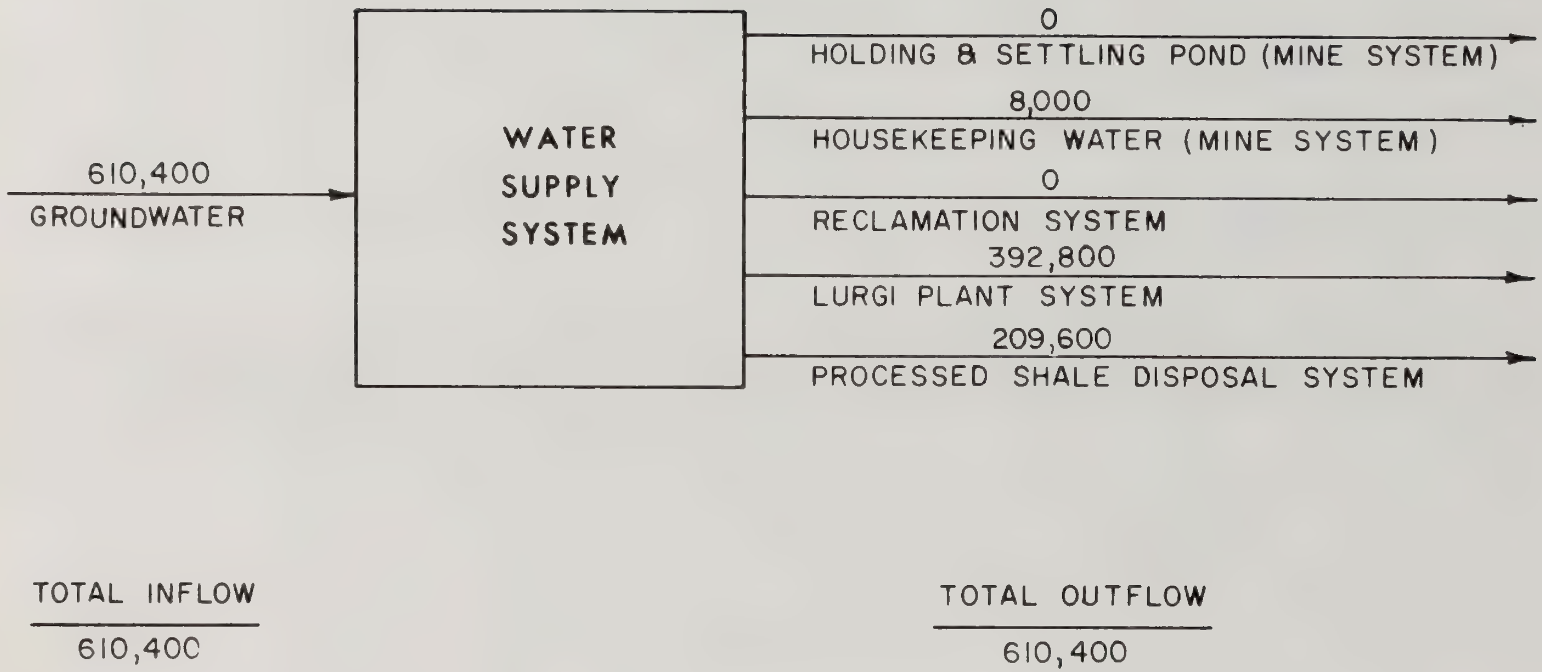



Figure 7-6-6
Water Supply System Water Balance - Operation Phase

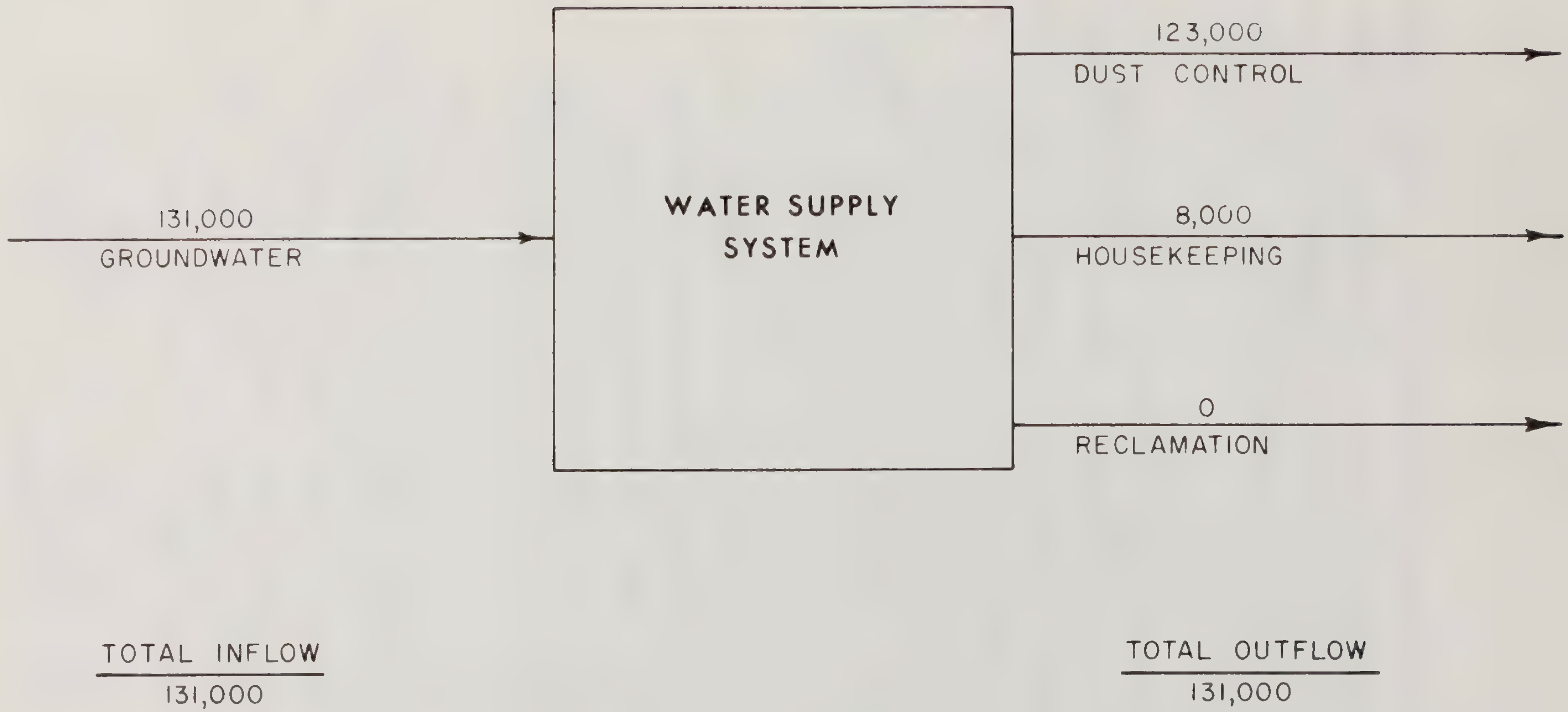



**Figure 7-6-7**
**Water Supply System Water Balance - Abandonment Phase**

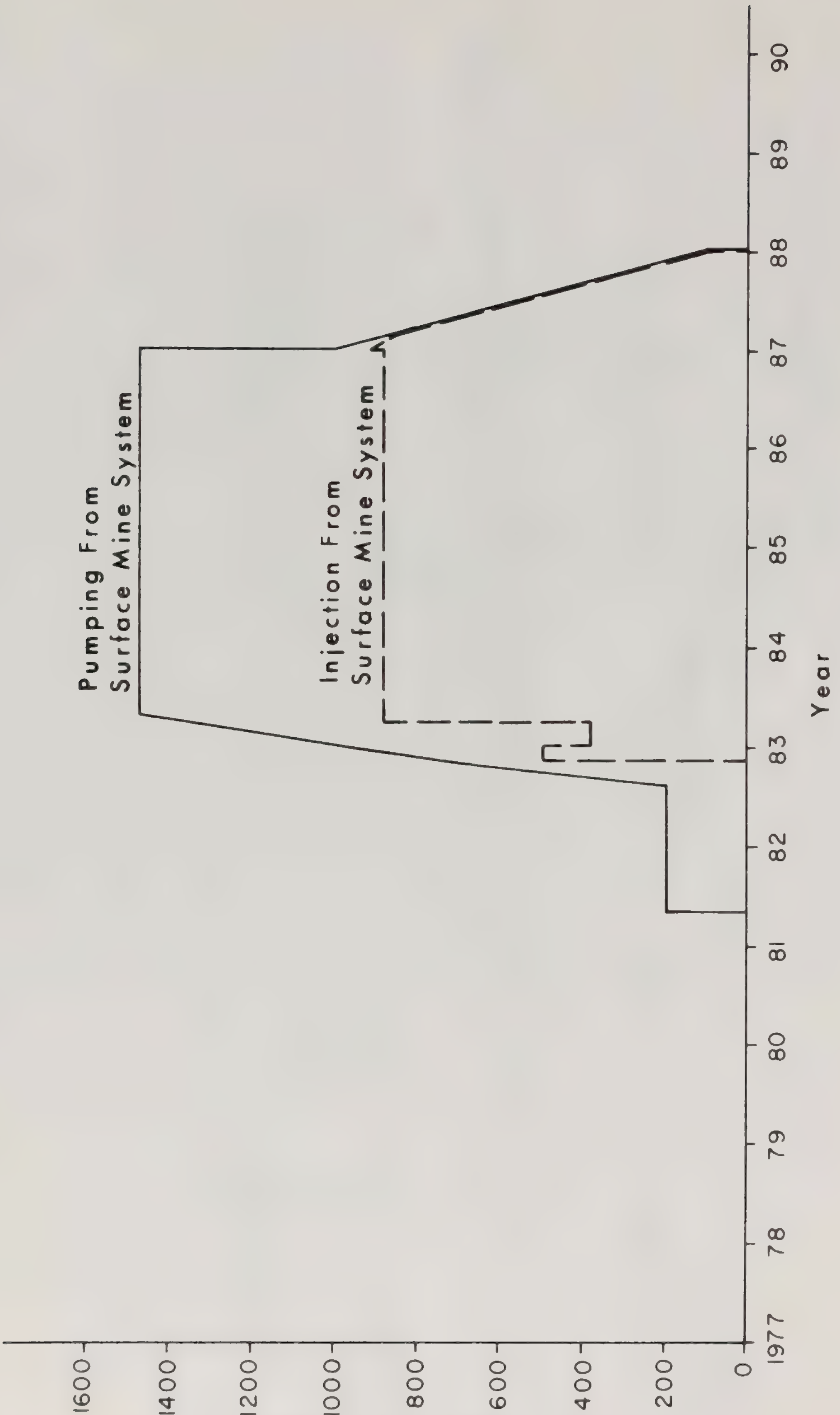



Figure 7-6-8
Combined Normal Mine Sump and Water Supply Well Pumping Rates

potable supplies. A water balance presenting normal water flows and requirements for the system for the construction, operation and abandonment phases respectively are shown in Figures 7-6-9, 7-6-10 and 7-6-11.

A. Construction Phase - The construction phase of mining is defined for water management purposes as the time from the initiation of support facilities construction until the first ore is removed. The initiation of actual mine excavation will occur about four months after the initiation of the construction phase.

1. Mine Water Sources - During the early period of the construction phase, essentially no water will be generated by the mining system. Very small amounts may be produced by penetration of isolated, highly localized water lenses in the overburden material or by intermittent precipitation into the pit. If these water inputs occur, they will be small, intermittent and undependable. Any such water will be collected and pumped from the mine into settling ponds to reduce sediment loads and for storage. The water will generally be used for dust control.

The first mine inflow water probably will be produced when the excavation intersects the A groove associated water-bearing zone. Therefore for design purposes it is assumed that no dependable water is generated by the system during construction, and any flow produced by the A groove associated water-bearing zone will be handled similar to the undependable supplies described above.

2. Mine Water Needs - The water supply system will be designed so that, during the contruction phase, it will be capable of supplying all mine system water needs. Any change in water needs will be satisfied by changes in distribution from the water supply system. Water pumped from the mine and stored in holding ponds may also be used to satisfy various water needs, resulting in temporarily reduced distribution from the water supply system.

a. Dust Control - The generally dry and disturbed conditions of the mine site and associated haul roads, diversion ditches and embankments,

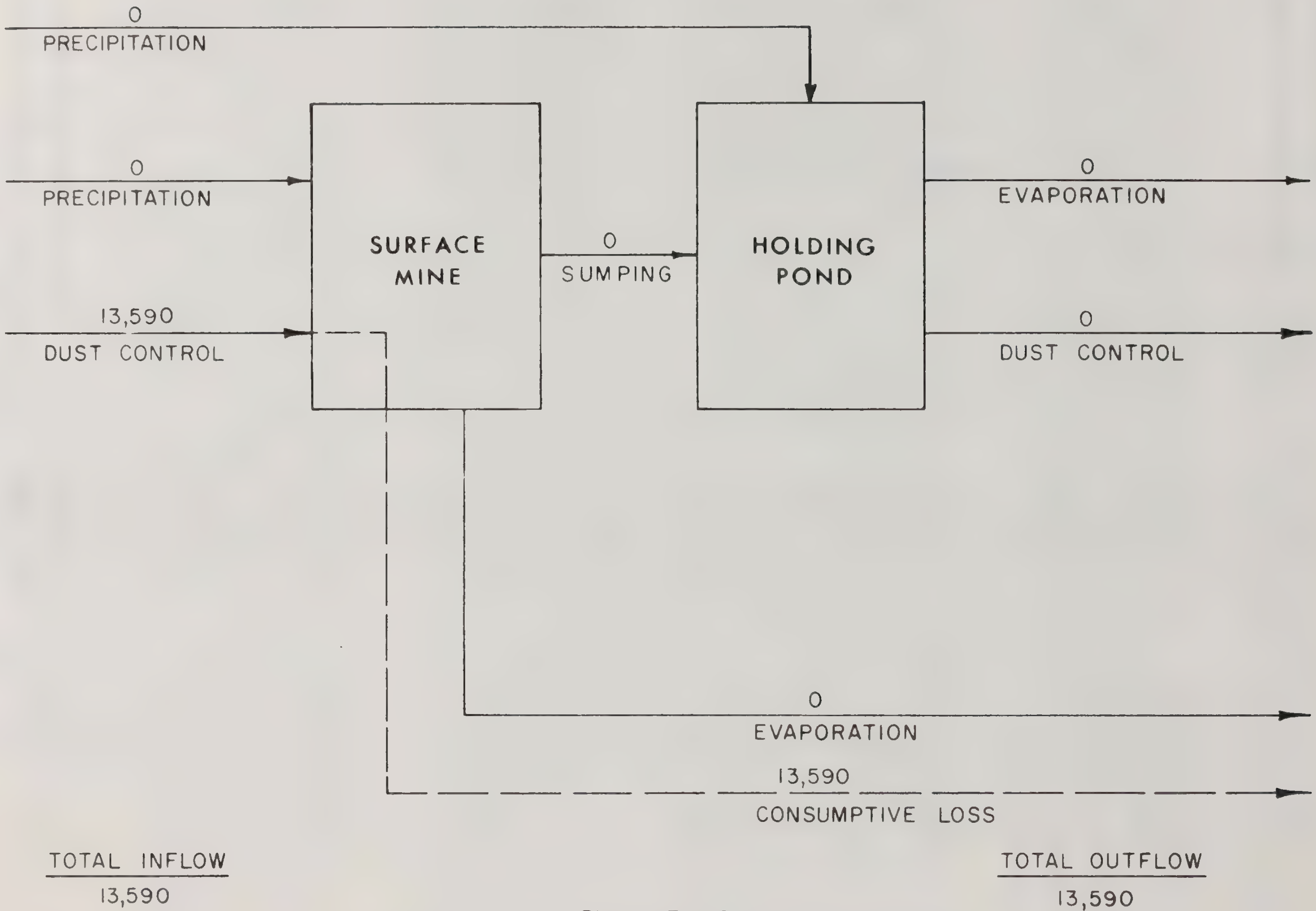



**Figure 7-6-9**
**Mine System Water Balance - Construction Phase**

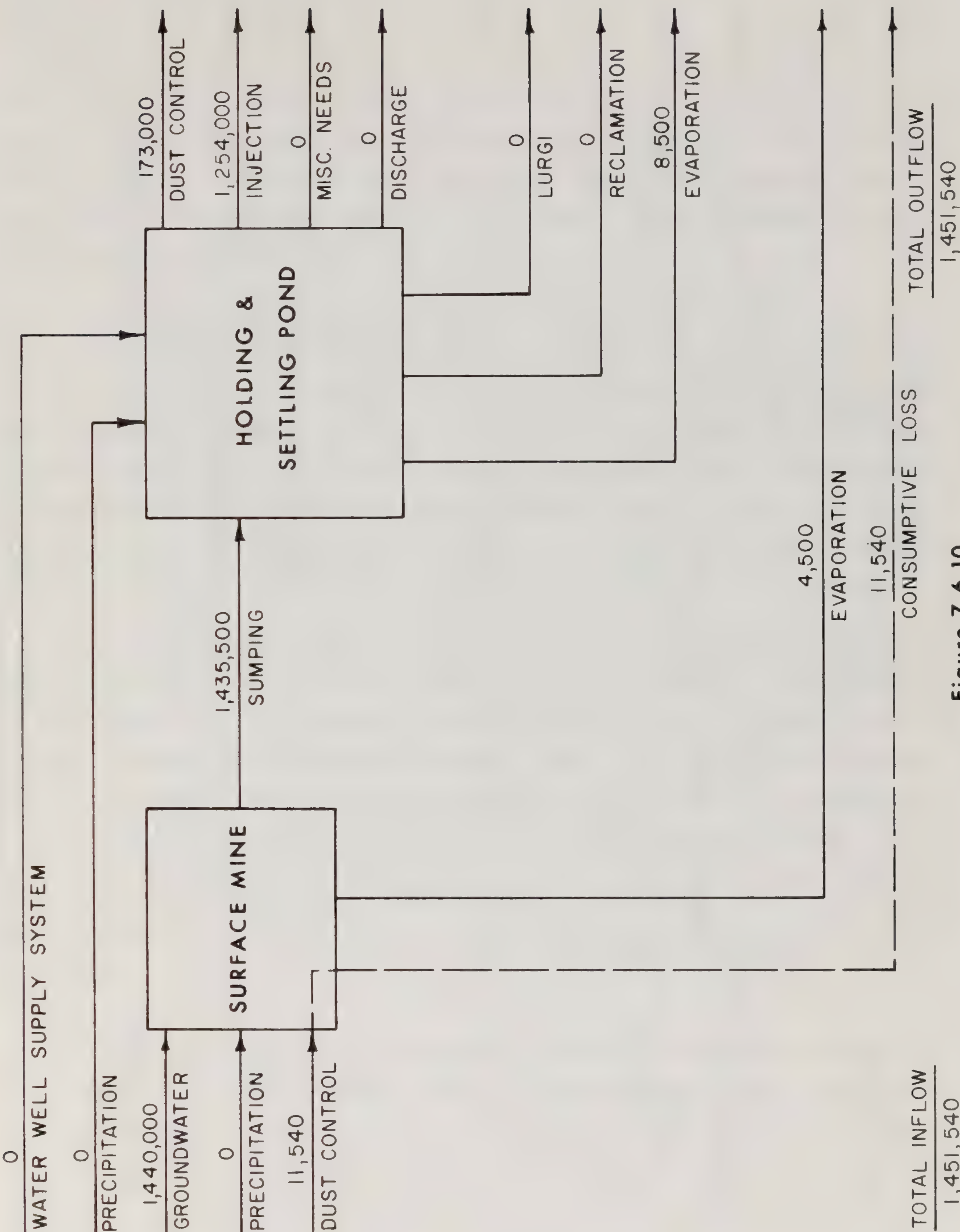



**Figure 7-6-10**
**Mine System Water Balance - Operation Phase**

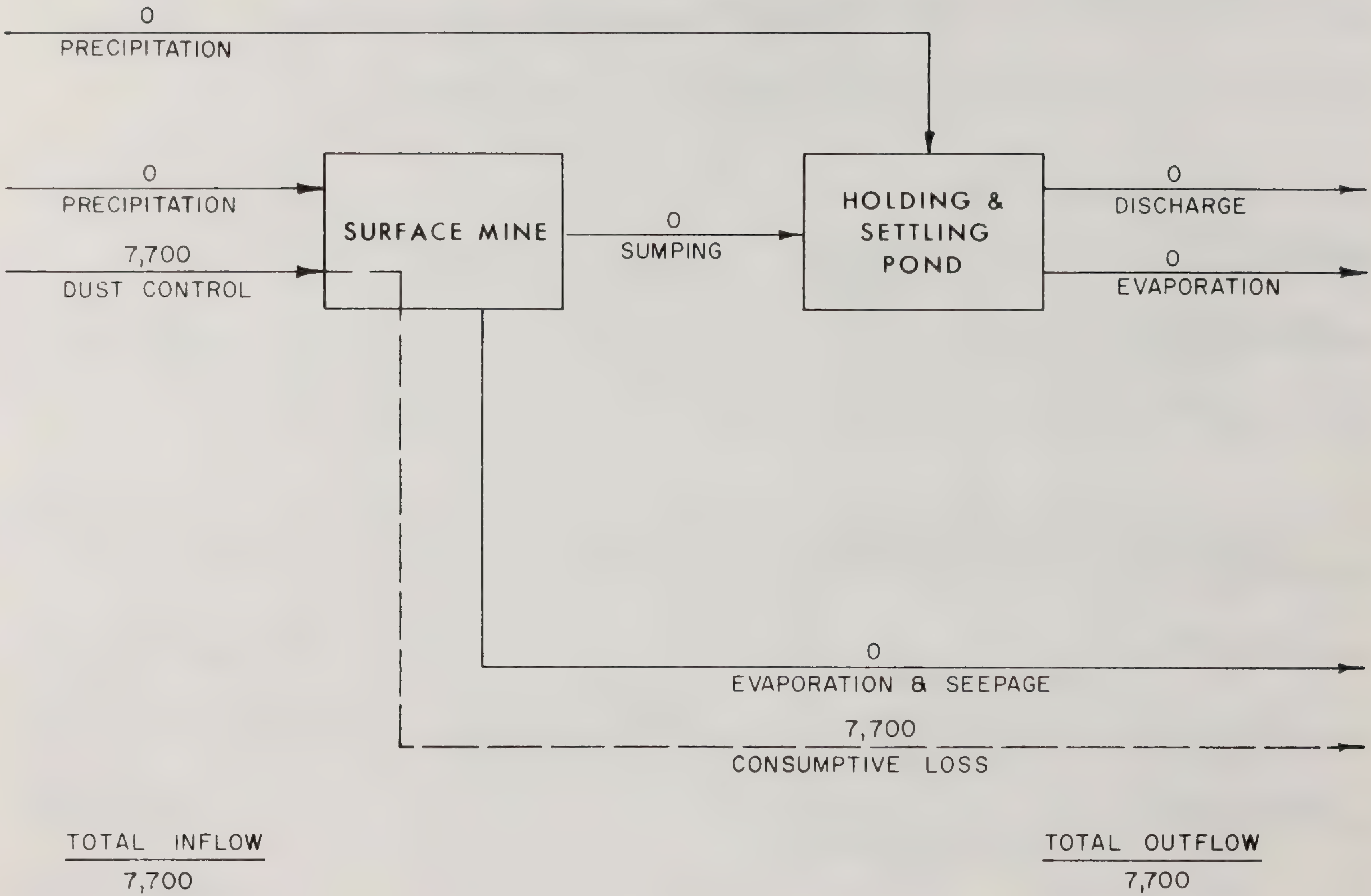



**Figure 7-6-11**
**Mine System Water Balance - Abandonment Phase**

topsoil and overburden stockpiles, ore stockpiles and other mining facilities will create dust during certain times of the year. Water for application to these areas for dust control will be provided from the mine holding ponds or the water supply system. The estimated maximum rate of water for dust control in mine and associated areas during the construction is 490,000 GPD. Actual rates of application will vary with season, precipitation inputs, evaporation rates and other factors. A normally expected demand for dust control will be 190,000 GPD.

b. Housekeeping and Potable Water - During construction, water will be required to provide drinking water and sanitary facilities for the workers. Bottled water probably will be purchased for drinking water needs and supplied in whatever quantity is necessary to supplement the available drinking water on tract. The remaining housekeeping water required, an estimated 8,000 GPD, will be provided by the water supply system. After use, this water will be transported to a properly licensed and designed package treatment plant where it will be treated and discharged from the system.

c. Reclamation - After removal from the mine area, overburden and topsoil will be stored on site for use during mine reclamation. Revegetation of these areas will be necessary during the storage period to reduce erosion losses. Although the revegetation program plans to utilize species that can survive on normal site precipitation inputs, irrigation will probably be required during unusually dry periods and during seed germination. This water will be supplied by water from the Upper Aquifer and lost from the system by evapotranspiration. The maximum expected demand will be 11,000 GPD, but normal flows will be zero since irrigation is expected to occur infrequently.

3. Mine Water Outflow - In the case of extreme precipitation events, or other unusual occurrences, excess amounts of water may accumulate in the mine system. Generally, this water can be stored in the mine system holding ponds and used to meet dust control water requirements, leading to a temporary reduction of water supply distribution rates. On these infrequent occasions it will be necessary to discharge the excess water collected in the mine

system holding pond to Dry Fork according to NPDES permit requirements. The maximum expected discharge will be 142,000 GPD.

B. Operation Phase - The operation phase of the mine system is defined for water management purposes as the period from initial to final ore extraction.

1. Mine Water Sources - At the initiation of the operation phase, ground water from the A groove water-bearing zone and from any intercepted perched water tables will be flowing into the mine. Four months after the initiation of the operation phase, the pit excavation will reach its maximum depth and water from the B groove water-bearing zone will flow into the pit. From this time until the completion of the operation phase, ground water flow to the pit will be essentially constant. The minimum expected ground water flow to the pit is 1,440,000 GPD and the maximum expected flow under extreme conditions is 4,320,000 GPD.

There will also be periodic precipitation inputs into the mine which will increase the water present. For a design event with a 100-year recurrence interval and 24-hour duration, this input is 1,867,000 GPD. However, precipitation inputs will be infrequent and normally will not contribute to the water supply.

Part of the water input to the mine will be lost directly from the pit by evaporation. The remaining water collected in the mine will be pumped to the mine system treatment lagoons for settling treatment prior to consumptive use or reinjection. Considering both ground water flow, and net precipitation the maximum anticipated flow into the pit is 6,187,000 GPD. The expected normal pit out flow is 1,436,000 GPD. Recommended pit pump capacity is 4,320,000 GPD.

2. Mine Water Needs

a. Dust Control - As in the construction phase, the generally dry conditions at the mine site and the associated haul roads, topsoil and overburden stockpiles, mine facilities and ore piles would create considerable dust without dust control. The estimated maximum demand for dust control water in the operation phase is 394,000 GPD. However, actual rates of application will vary with meteorologic conditions and a normal flow of 173,000 GPD is expected. The required water will be supplied from the mine system treatment lagoons. On very rare occasions, these lagoons might not be able to supply sufficient quantitites of dust control water. Under these circumstances, the required water would be supplied by the water supply well system.

b. Housekeeping and Potable Water - The potable water system for the operational phase will be identical to that of the construction phase.

c. Reclamation - The growth of reclamation vegetation on the mine related facilities such as haul roads and topsoil stockpiles during the operation phase of the mine system generally will not require irrigation. However, during extremely dry periods, irrigation water may be necessary. Concurrent with the mine operation phase, shale will be processed and processed shale waste will be produced. Revegetation of processed shale will be occurring and will also periodically require irrigation water. All irrigation water will be drawn initially from the mine system treatment lagoons. If additional water is required, it will be drawn from the water supply well system. Maximum expected design flow will be 11,000 GPD. Normal flows will be zero.

3. Mine Water Outflows - Excess water in the mine system will be accumulated in the mine system treatment lagoons and consumed on site or disposed of by one of two methods: reinjection into the Upper Aquifer; or discharged to Dry Fork.

a. Reinjection - A system of injection wells associated with the existing MIS facility are located south and east of the MIS system site. Since the MIS operation may be abandoned about the time that the operation phase of the Lurgi Demonstration Project is initiated, these wells will be available for excess water disposal from the mine system. These wells are located as shown in Figure 7-6-4. The maximum injection capacity of the system is 4,752,000 GPD, which is capable of disposing the normally expected disposal flow of 1,254,000 GPD even if the MIS program were to continue.

b. Discharge to Dry Fork - As noted, the primary method of excess water disposal will be injection. If, however, the amount of water to be disposed exceeds the capacity of the injection system, the additional volumes will be discharged to Dry Fork. The normally expected discharge rate is zero. The maximum expected discharge rate is 6,309,000 GPD.

## 6.3 LURGI PROCESSING SYSTEM

During construction of the Lurgi facility, water will be required for such activities as concrete preparation, dust control and other construction related processes. During the operation phase, the Lurgi plant will process the mined ore and will require substantial amounts of water for cooling and other purposes. The Lurgi facility will also generate water sources from precipitation runoff and from processing. Water balances for normal flows during construction, operation and abandonment phases are presented in Figures 7-6-12, 7-6-13 and 7-6-14, respectively. The design and normal flows are also presented in Figures 7-6-1, 7-6-2 and 7-6-3, respectively.

### A. Construction Phase

#### 1. Process Water Sources

a. Storm Runoff - During construction, precipitation will occur intermittently on the site. When the precipitation occurs above certain intensities, runoff will be produced creating a system generated water source. For a design storm of 10-year recurrence interval and 24-hour duration, an input of 1,662,000 gallons will occur. Of this amount, 957,000 gallons will run off with the remainder being lost from the system by percolation and evaporation.

b. Lagoon Precipitation - The treatment facility for construction waste water at the Lurgi site will probably be an aerated lagoon. Periodically, precipitation will fall on the lagoon area, adding additional water into the system. For a 100-year, 24-hour design storm, this input is 32,400 gallons. However, since precipitation in the site area is infrequent, this water input to the system will normally be zero.

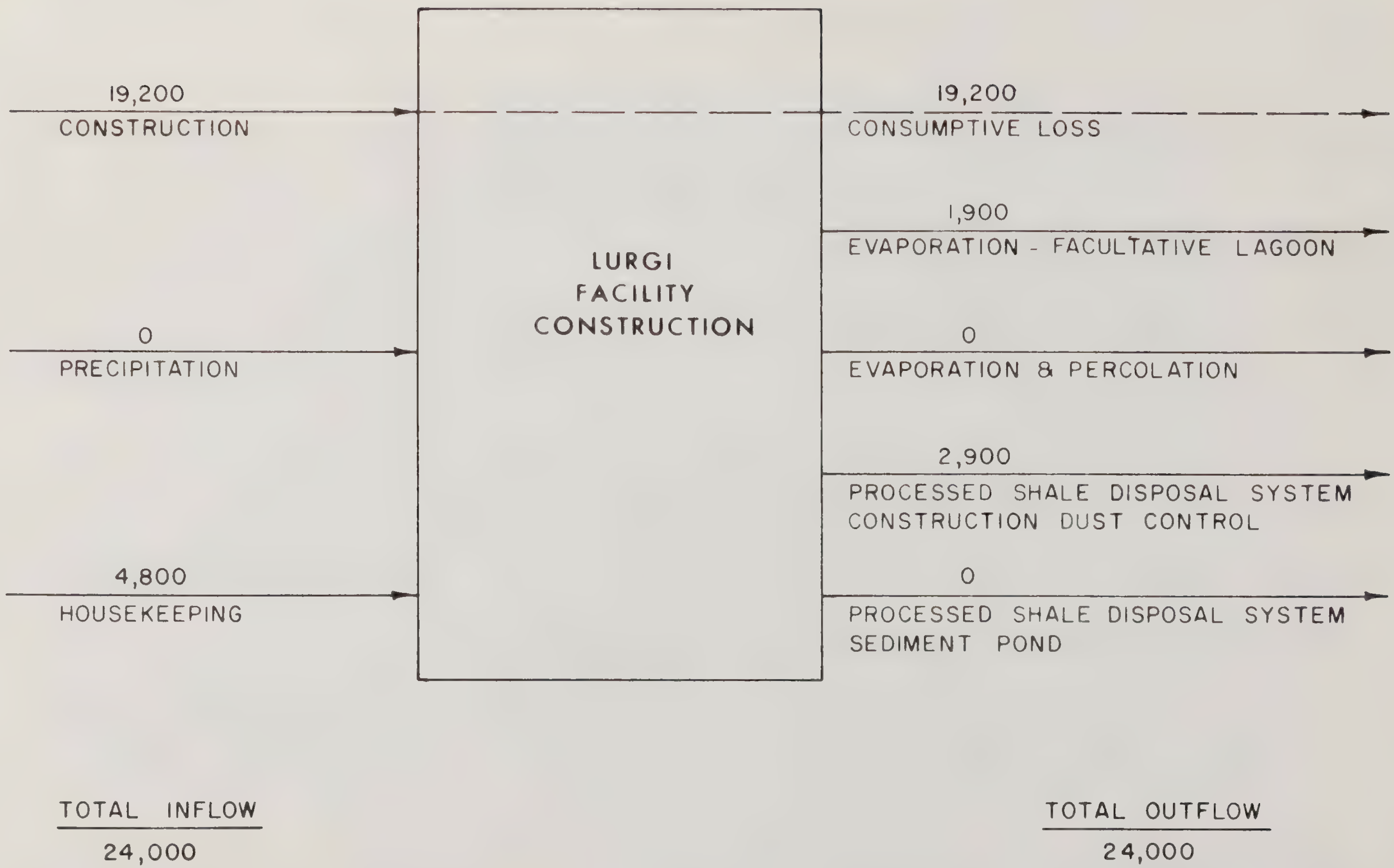



**Figure 7-6-12**
**Lurgi Process System Water Balance - Construction Phase**

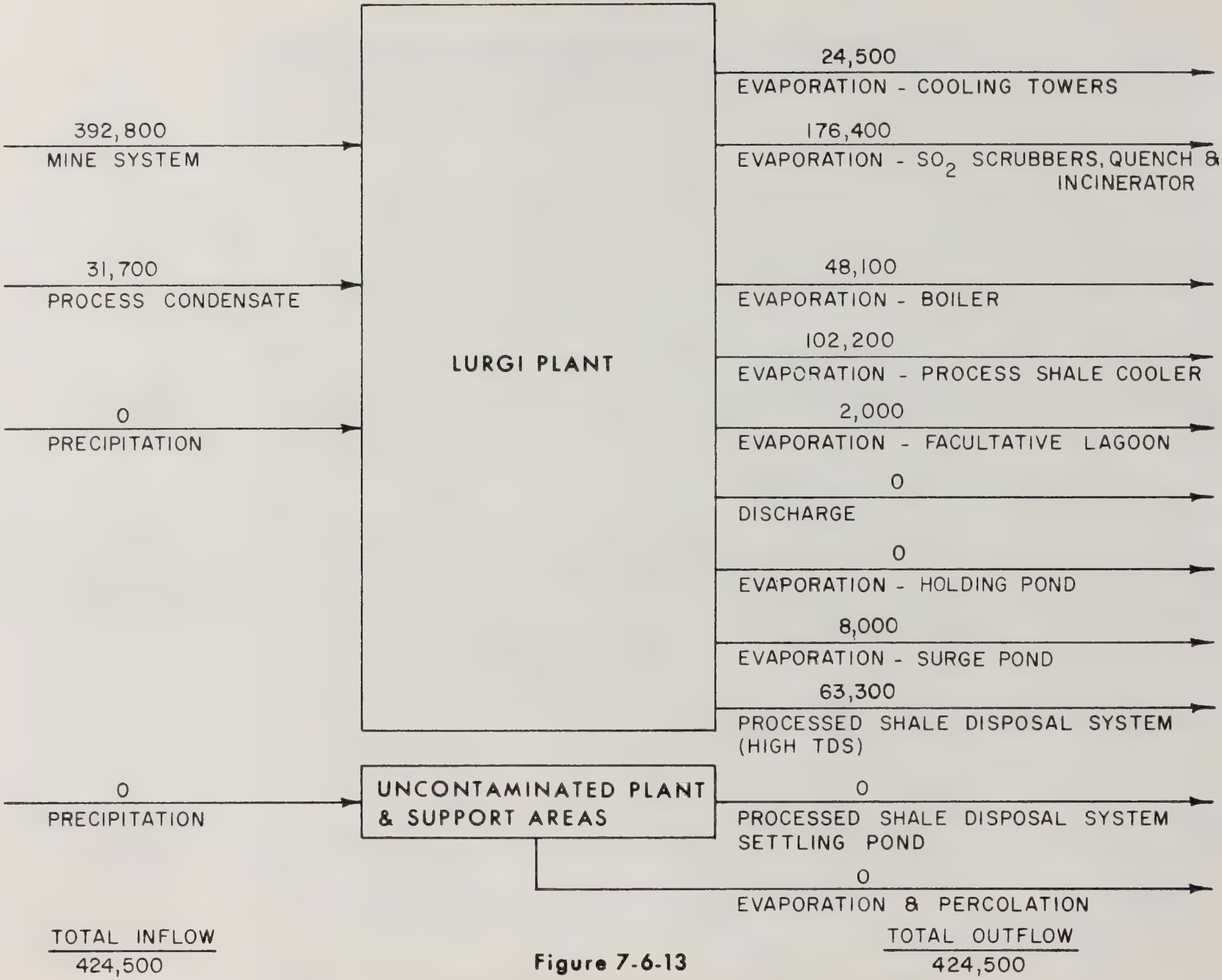



**Figure 7-6-13**
**Lurgi Process System Water Balance - Operation Phase**

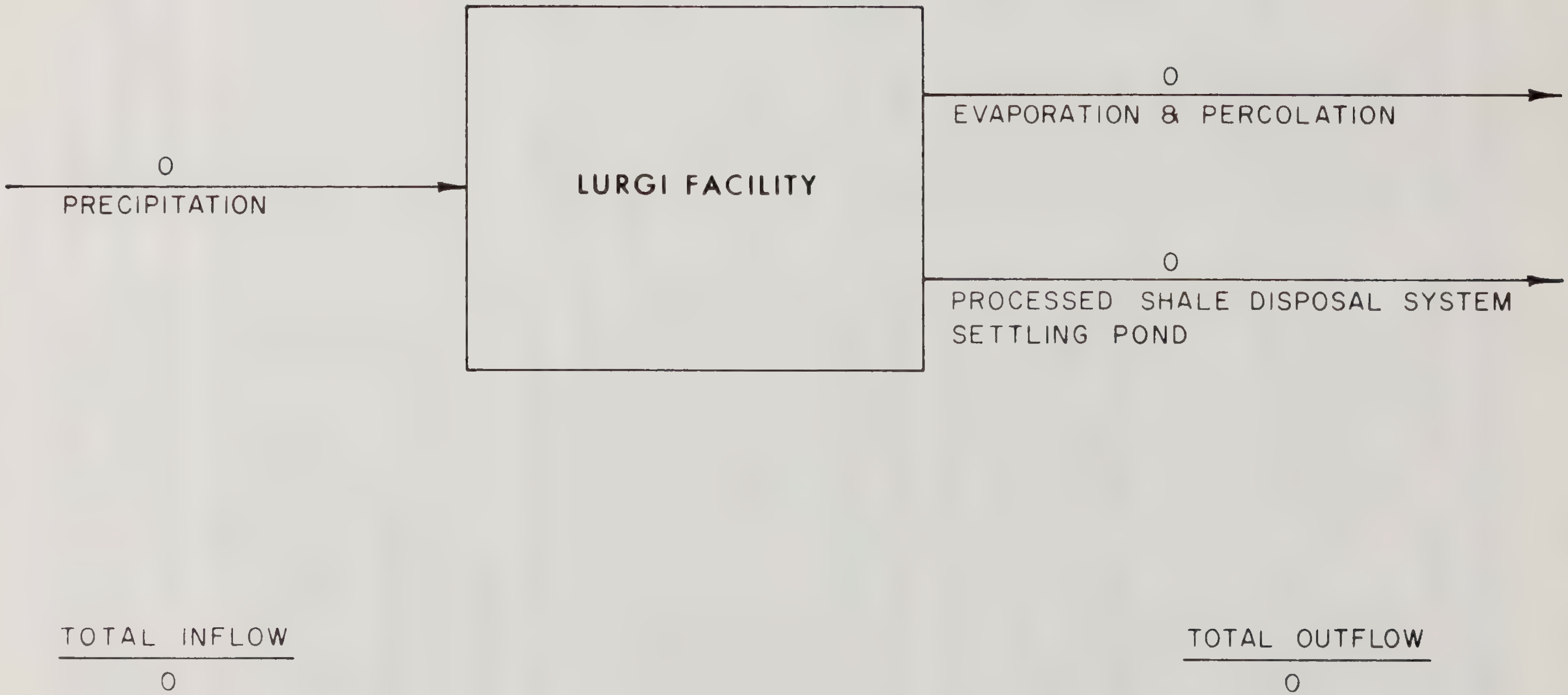



Figure 7-6-14
Lurgi Process System Water Balance - Abandonment Phase

2. Process Water Needs

a. Construction Water - During the construction phase of the Lurgi processing plant, water will be required for various construction procedures, such as mixing concrete and dust control. A maximum expected demand for this water is 48,000 GPD. However, these water needs will be intermittent and will vary in required quantities. The expected normal flow is 19,000 GPD. The required water will be taken from the water supply system at the required rates of usage.

b. Housekeeping and Potable Water - Water will be required during construction for drinking purposes, sanitary facilities and for other miscellaneous activities. Bottled water will supply all drinking water at whatever rate is required. The demand for sanitary facilities water will vary over time but, based on the expected number of personnel, a maximum design requirement of 9,600 GPD and a normal expected flow of 4,800 have been estimated. This flow will be supplied at the actual required rates from the water supply system.

The sanitary waste stream produced at the Lurgi construction site will probably be directed to an aerated lagoon for treatment. This lagoon may be the same one utilized for biological treatment in the operation phase of the Lurgi process. The facility will have the capability of treating water flows in excess of the 9,600 GPD design rate. The option of utilizing a package treatment plant remains.

3. Process Water Outflows

a. Area Runoff Discharge - Natural drainage of the majority of the site area is to the northeast toward the processed shale disposal area. Therefore, runoff generated by storm events will be diverted around the processed shale disposal system. As previously noted, the flows will be intermittent and vary in rate due to varying precipitation input, but the flow for the design storm input will be 957,000 GPD.

b. Treated Sewage Discharge - Since it is planned to treat the Lurgi construction site waste water by aeration, water will be lost to evaporation. Assuming that there will always be water in the aeration lagoon, the expected evaporation rate is 2,000 GPD. Therefore after treatment, a design flow of 42,000 GPD and a normal expected flow of 3,000 GPD will still require discharge from the treatment facility. This water will be transported to the processed shale disposal system for use as embankment construction water. If the treatment system produces effluent at a rate in excess of required construction water, the additional water will be discharged to Corral Gulch under NPDES permit. However, the design and normal discharges from the aeration lagoon are much smaller than the design and normal construction water requirements. Therefore, discharges to Corral Gulch should be infrequent. If the option of using a package treatment plant is selected the treated water would be discharged under NPDES.

B. Operation Phase - During operation, two water flow systems will be active at the Lurgi processing site. The first will be the flow of water through the Lurgi plant. The second will be the precipitation-runoff-discharge system for precipitation on disturbed areas surrounding the plant facilities.

1. Plant System

a. Process Water Sources

1) Surface Runoff - Intermittent precipitation will occur on the Lurgi facilities area creating runoff. In certain facility areas such as the Lurgi plant area, crushed shale storage area, administration area shops, the raw water treatment facility, boiler sites and the product containment area, water has the potential to pick up hydrocarbons. Runoff from these areas will be collected and directed to the facility waste treatment system.

For a 100-year, 24-hour design storm precipitation, an input of 14,400 gallons is estimated. Because the plant area is generally paved and contains a storm drainage system that carries the runoff from the area, evaporation and seepage losses will be minimal and runoff volumes will essentially be equal to the precipitation input. This system will also capture facility washdown water which flows into runoff collection systems in the plant area. However, this flow will be small compared to design runoff flows, and will be zero during those events. Therefore, the input to design and normal flows from washdown is approximately zero.

2) Facultative Lagoon Precipitation - Intermittent precipitation will occur on the facultative lagoon used for biological treatment of water during the operation phase. This water will then enter the waste stream and require consumption or discharge. For a design storm with a 100-year recurrence interval and 24-hour duration, this input will be 32,000 gallons. However, because precipitation events are infrequent, there will be no normal input expected from this source.

3) High TDS Holding Pond Precipitation - The Lurgi water treatment system produces a high TDS concentration waste stream (described in Section 4, Chapter 3) comprised of brines and blowdowns from the facilities. This waste stream will be diverted to a surge pond. This pond will periodically receive precipitation, adding water to the waste stream. For the 100-year, 24-hour design storm, this input will be 283,000 gallons. Normal precipitation inputs will be zero. Another holding pond for the oily waste water treatment system will periodically receive 353,000 gallons.

4) Process Condensate - The mined shale ore contains residual water which is freed during processing. This water is collected in the Lurgi processing systems and discharged to the waste treatment system. If the facility is processing shale at 100% capacity, the design production rate of water will be 41,500 GPD. The normal production rate will be 31,700 GPD.

b. Process Water Needs - The water required for operating the Lurgi processing facility will be supplied from a water supply well system or the mine system treatment lagoons and will recycle as much process water as is feasible, as described in Section 4, Chapter 3. The required design flow for 100% capacity operation of the processing plant is 600,200 GPD with a normally expected demand of 424,500 GPD. On a normal basis, the demand will be supplied by 31,700 GPD from stripper condensate and 392,800 GPD from water supply system wells or the mine system holding pond.

c. <u>System Water Outflows</u> - During oil shale processing, a large portion of the process water stream used for cooling purposes will be lost to evaporation. The remainder will flow through treatment facilities. Waste water from the Lurgi processing system is accumulated in two separate streams. One stream is comprised of blowdown from the cooling towers, boilers, and the $SO_2$ scrubber, where large evaporative losses occur, and backwashes from the water treatment system. The water at the end of the stream, therefore, has relatively high TDS concentrations (estimated to be about 10,000 ppm) and should be compatible for moisturizing processed shale. The second stream is used for utility washdown and contains distillate from the ammonia stripper condensate and oily runnoff. This water will undergo tertiary treatment and be consumed in cooling processed shale or another acceptable use.

1) <u>Evaporation Losses</u> - Evaporative losses will occur during oil shale processing from such facilities as the cooling tower, the $SO_2$ scrubber, steam system, the processed shale cooler, the waste treatment lagoon and the high TDS holding pond. The ammonia stripper concentrate may be incinerated, evaporated or disposed offsite by special contract. In this discussion, this waste stream is considered an evaporative loss regardless of the disposal method. The expected maximum design loss from evaporation is 600,000 GPD. Actual rates will vary with climatic conditions and plant operations rates. A normal evaporative loss of 361,000 GPD is expected.

2) <u>High TDS Water Consumption</u> - Water used during processing for such purposes as $SO_2$ scrubber and cooling tower blowdown, will probably contain TDS concentrations of about 10,000 ppm. This water will be collected, stored, and used for moisturizing the processed shale. Inflows to the storage pond will normally be 71,300 GPD, with a design flow of 89,100 GPD. Evaporation losses, which are considered in the above section, will occur from the pond. Occasional precipitation inputs will also occur. Therefore, outflow rates from the pond to the processed shale disposal system will have a design value of 147,600 GPD and a normally expected value of 63,300 GPD.

3) Tertiary Treated Water Discharge - Under normal conditions, this stream of 87,000 GPD will be utilized in the processed shale cooler, where evaporative losses will be sufficient to dispose of the entire stream. Occasionally, quantities of tertiary treated water may accumulate in excess of consumptive uses. This excess water will be consumed in an acceptable manner or discharged to Corral Gulch after testing to insure conformance with discharge permit requirements.

2. Associated Closed Subsystem - Precipitation generated runoff will also occur on Lurgi process system areas not containing product hydrocarbons or directly related to the Lurgi plant. However, because the flows are on a disturbed area which will contribute some sediment load, they will be collected for treatment, and thus represent a site-generated water source. A 10-year, 24-hour storm on this area would create a precipitation input volume of 1,222,000 gallons. A portion of this rainfall, 741,000 gallons, will appear as runoff, with the remaining 481,000 gallons being lost to evaporation and seepage.

This runoff will be diverted to flow into the processed shale disposal system settling pond.

## 6.4 PROCESSED SHALE DISPOSAL SYSTEM

After the oil products are removed from the mined shale by the Lurgi processing operation, the processed shale will require disposal. This will create water demands during various stages in the construction and operation of the disposal site. Source streams will be generated on site by precipitation events, and by transportation to the site from the water supply well, mine and Lurgi process systems. Processed shale disposal will be conducted in two phases. The first phase will test several disposal techniques to determine the optimum disposal system. Also during this period, tests will be run to determine the erosion potential for processed shale, and to determine processed shale leachate quality. The selected Phase II disposal system will depend on the results of the Phase I studies. The water flow systems for Phase II will be identical to that of Phase I, with two differences. First, Phase II will not require water inputs for the leachate testing. This reduced demand will be accommodated by reducing pumping from the water supply system wells or the mine system holding pond. Second, the contributing area for evaporation and runoff from the processed shale pile and the disturbed areas may change. This could alter the sizing of the Phase II processed shale evaporation pond, if required, and the disturbed area sediment pond. Otherwise, the system will remain the same. The present proposed water management plan is based on the Phase I design. The water balances presented in Figures 7-6-15, 7-6-16 and 7-6-17 are Phase I water balances.

A. Construction Phase

1. Processed Shale Embankment Water Source - Periodically, precipitation may occur over the disturbed construction area of such intensity that runoff will occur, generating a water source stream. This flow will be intermittent and will vary in rate. For the 10-year, 24-hour design storm, which will input a precipitation volume of 12,000,000 gallons, a runoff volume of 1,744,000 gallons will be generated. The remainder will be lost to evaporation and percolation.

2. Processed Shale Embankment Water Needs - During the construction phase, water will be required for dike construction and dust control. The rates of required water will vary over time, and all inputs will be consumed by incorporation in the dike material or by evaporation. The anticipated required rate is 69,700 GPD. Treated sanitary effluent produced during construction of the Lurgi processing system will be used for this purpose. Any additional water required will be supplied by the water supply system at the actual demand rates.

3. Processed Shale Embankment Water Outflow - The periodic runoff generated by precipitation over the construction site will be diverted to a settling pond (number 13 in Figure 7-6-4). This pond will also provide sediment reduction treatment for the Lurgi plant construction area runoff. Water will be lost from the pond by evaporation, seepage or discharge to natural surface drainage. The pond will be capable of storing the 2,701,000 gallon design flow from both sources. Inflows into the pond will occur only during precipitation events, so normal inflow is zero.

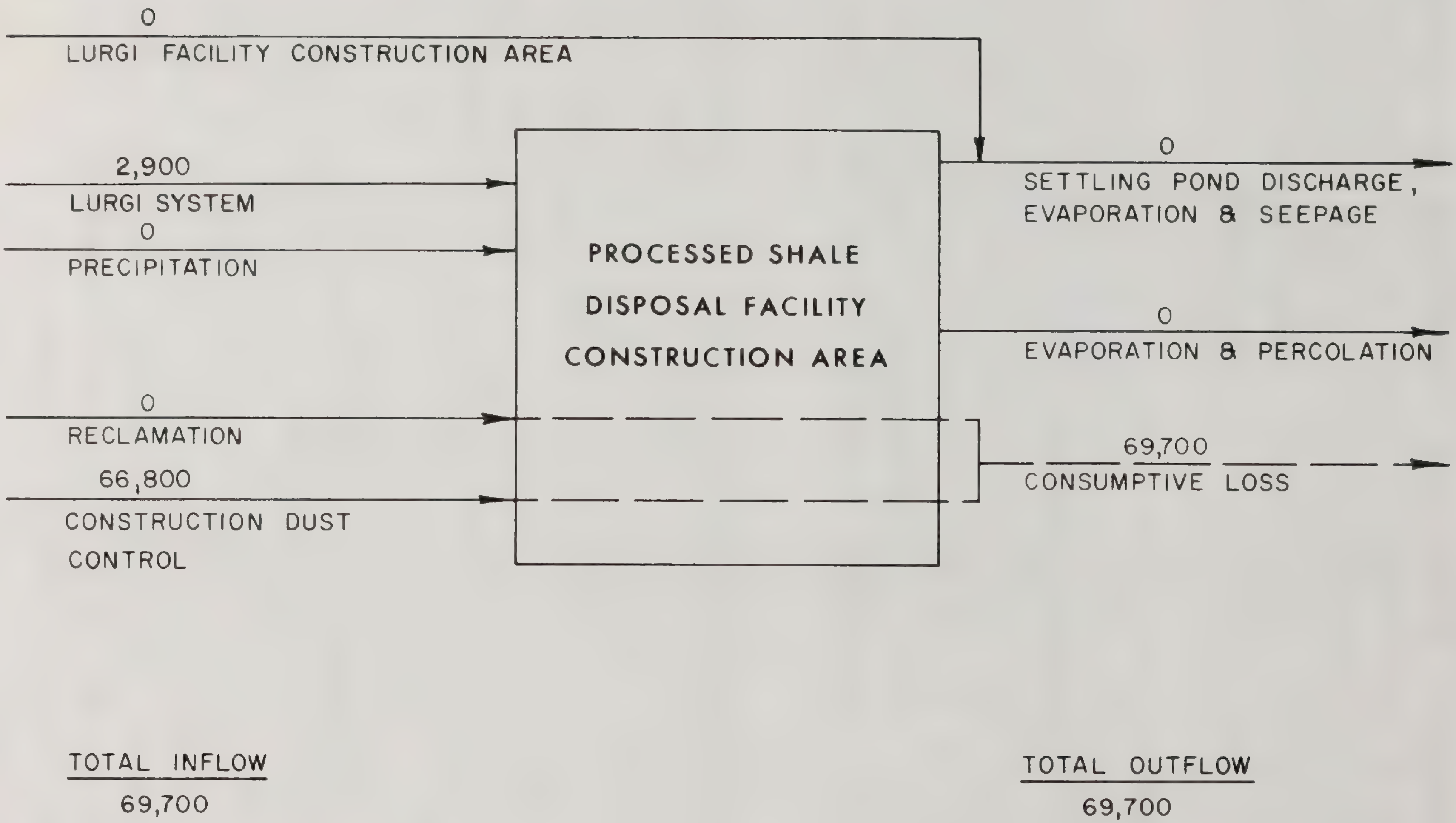



**Figure 7-6-15**
**Processed Shale Disposal System Water Balance - Construction Phase**

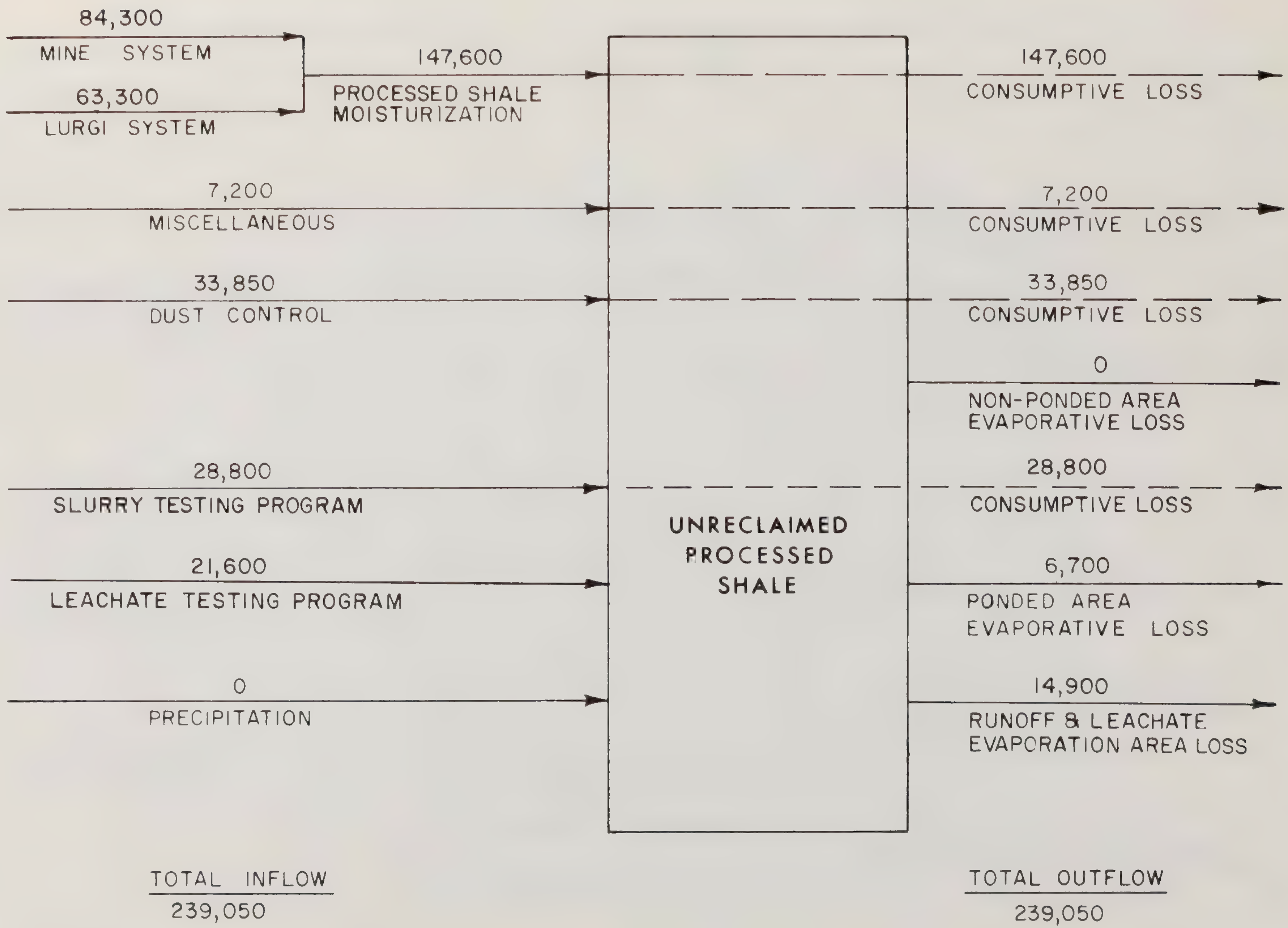



**Figure 7-6-16 (1 of 2)**
**Processed Shale Disposal System Water Balance - Operation Phase**

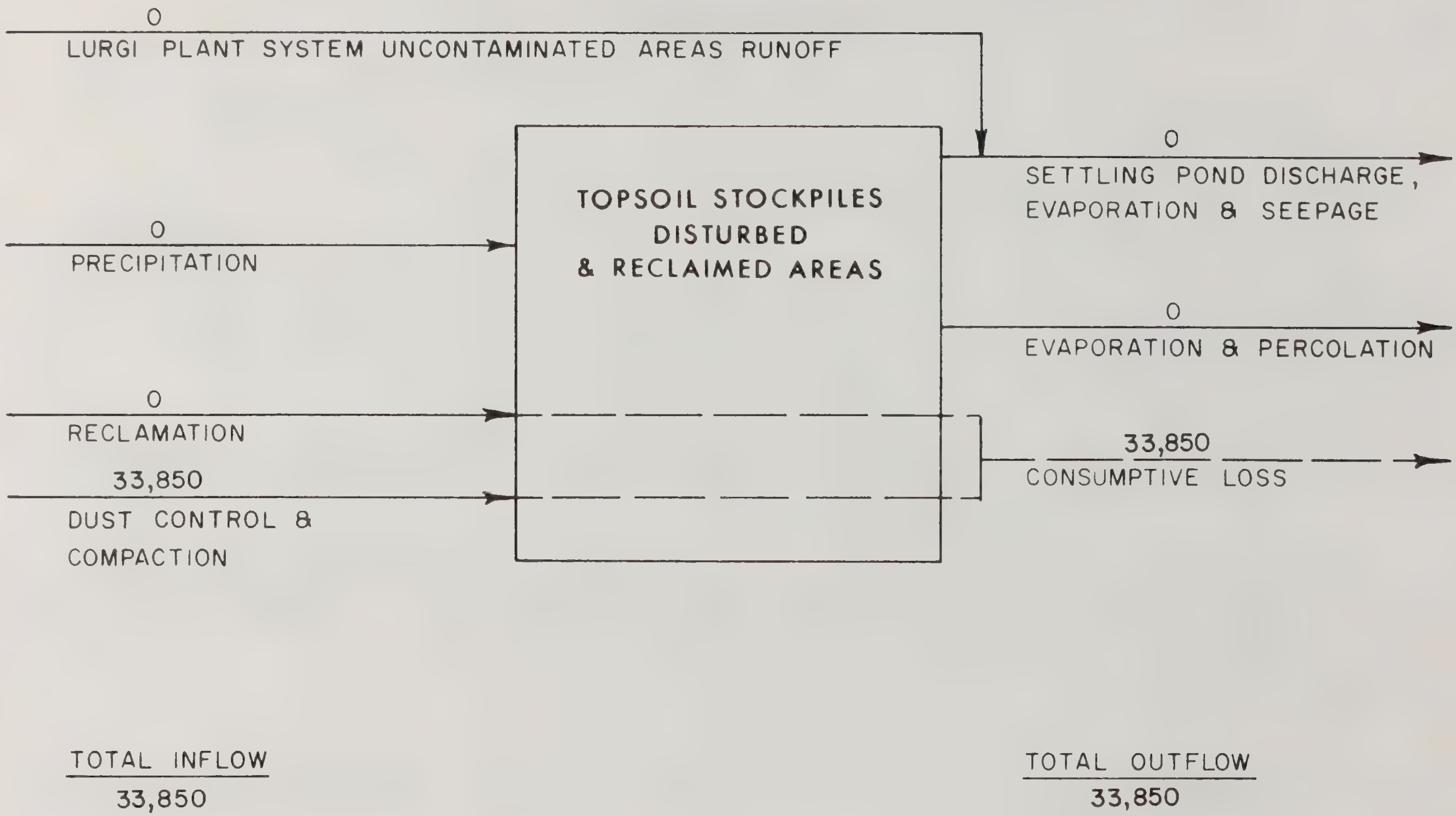



**Figure 7-6-16 (2 of 2)**
**Processed Shale Disposal System Water Balance - Operation Phase**

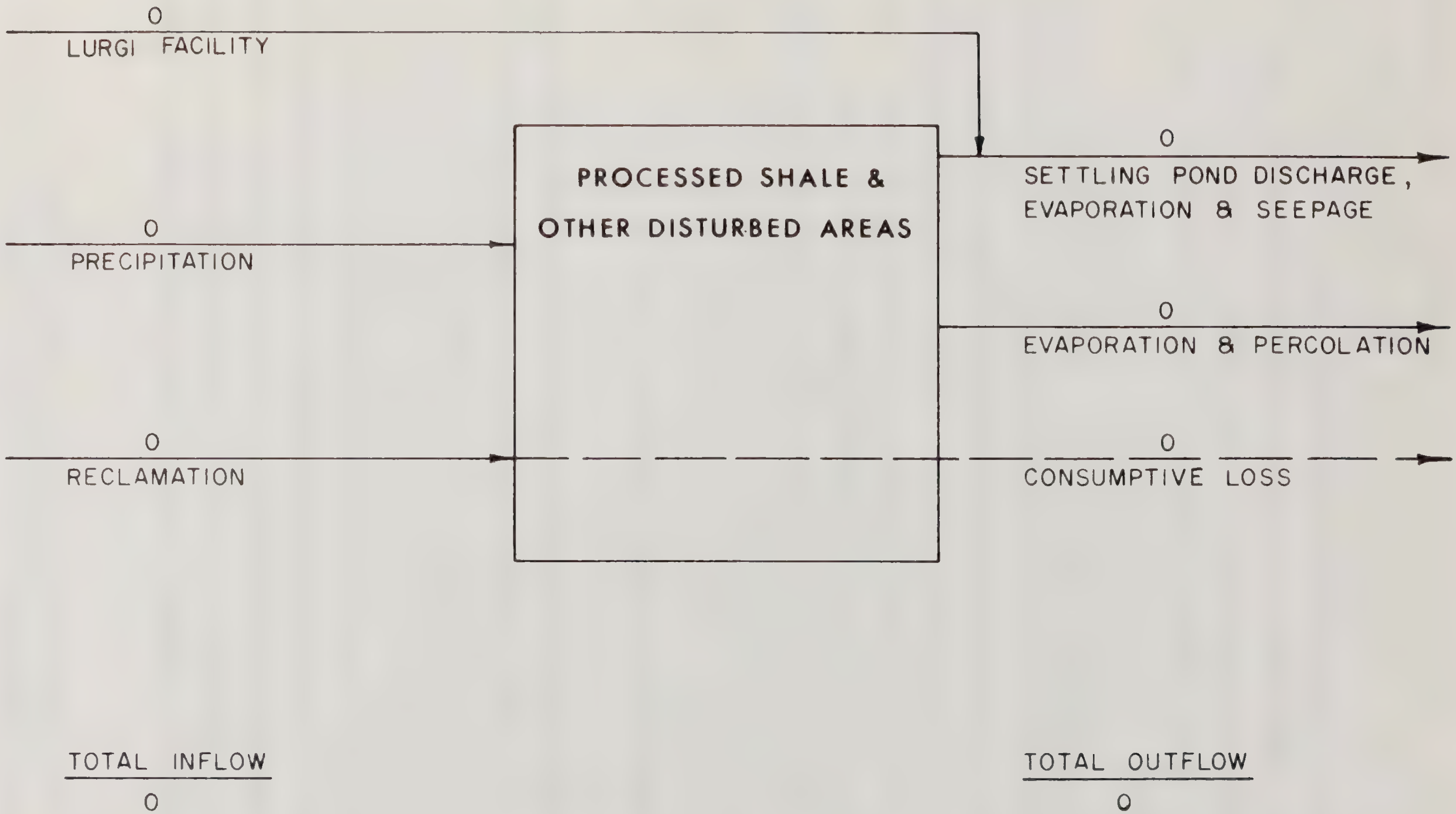



Figure 7-6-17
Processed Shale Disposal System Water Balance - Abandonment Phase

B. Operation Phase - There will be two flow systems active at the processed shale disposal site during the operation phase. One system will incorporate flow inputs for dust control, compaction, processed shale moisturization, testing programs and precipitation on the disposed shale. The second system will include the runoff and discharge of precipitation on disturbed and reclaimed areas.

1. Major System

a. Processed Shale Pile Water Source - Precipitation will periodically occur on disposed, unreclaimed processed shale. Because the quality of the water which has been in contact with the waste shale cannot be accurately estimated, all such water, including runoff and leachate, will be collected and prevented from entering the natural ground water system. These flows will occur only periodically, and will have varying rates. For a 100-year, 24-hour design precipitation volume of 1,800,000 gallons, a runoff flow of 1,020,000 gallons will be produced which will be collected and evaporated. The remaining 780,000 gallons will be lost to evaporation.

b. Processed Shale Area Water Needs

1) Construction and Dust Control - The processed shale pile is a disturbed area which, under dry conditions, could become a source of fugitive dust. To prevent dust production, the shale pile periodically must be watered. Areas within the disturbed flow system, such as topsoil sites, will also require water treatment to control dust. Additional water will be necessary for the construction of new dikes during the disposal operation. All of this water will be consumed by incorporation into the site material or by evaporation, and lost from the system. The expected required rate for these two needs is 68,000 GPD. The water will be supplied at the actual required rates from the water supply well system or the mine system treatment lagoons.

2) Processed Shale Moisturization - The processed shale produced by the Lurgi process is extremely fine and dry. For efficient disposal, it is therefore necessary to moisturize this material. The amount of water

required for such moisturization will vary with the production rate of processed shale and with the amount of moisturization required for disposal. At full production capacity, and using a design moisture input of 25% by weight, a flow of 239,700 GPD will be required. Using a normal expected value of 17.5% moisturization, demand will be 147,600 GPD. This water will be supplied from high TDS water from the Lurgi processing system and from the water supply system wells or the mine system treatment lagoons.

3) Miscellaneous - Small amounts of water will be required for various consumptive uses at the processed shale disposal site. The maximum expected demand will be 7,200 GPD. This need will be supplied at actual required rates from the mine system treatment lagoons and the water well supply system.

4) Leachate Testing Program - As part of the processed shale disposal facility, Phase I operations, testing will be conducted to determine leachate water quality. Because site rainfall events generally are infrequent, and rarely are of sufficient intensity and duration to generate leachate, ponding studies to induce leachate are planned. Water will be required to maintain ponded conditions at an expected rate of 21,600 GPD.

Because ponded water is maintained on the test area, evaporation losses will occur constantly. The expected evaporation loss rate will be 6,700 GPD. Initially, all water not evaporated will enter the processed shale and be stored in the shale material. Eventually, however, some of the infiltrating water should penetrate the shale material, and accumulate at the bottom of the test material as leachate. Because a constant ponding head pressure will be maintained, a constant leachate production rate equal to the application rate minus evaporation losses should develop. The expected equilibrium leachate flow rate is 14,900 GPD. This flow will be collected periodically, measured, analyzed for water quality and disposed of according to water quality.

5) Slurry Testing Program - As part of the Phase I operations, the feasibility of processed shale transport to the disposal site by slurrying techniques instead of by conveyor belt will be investigated. Therefore,

additional water will be required for utilization in the slurry transport testing program. The additional water is expected to be necessary at a rate of 28,800 GPD and will be supplied from the water supply wells or the mine system treatment lagoons.

6) Reclamation - As previously noted, the revegetation of topsoil stockpiles and reclaimed processed shale areas will not normally require irrigation. In extremely dry periods or during seed germination, however irrigation may be necessary. If such a situation occurs, irrigation water will be drawn from the water supply wells on the mine system treatment lagoons.

c. System Water Outflows - Any runoff, natural leachate and any excess experimentally induced leachate which occurs will be diverted to an appropriate pond, depending on water quality. Initially the water quality might require evaporation. Otherwise, it could be used for dust control or mixed with the high TDS water.

2. Associated Closed System

a. Disturbed and Reclaimed Area Runoff - Precipitation events will periodically create runoff from disturbed and reclaimed areas at the disposal site. This will generate a water source stream which must be treated to remove sediment. The flows will be intermittent, and will vary in rate. For a 10-year, 24-hour design storm (10,780,000 gallons), a runoff volume of 1,274,000 gallons will occur with the additional 9,506,000 gallons being lost to evaporation and seepage. The runoff will be diverted to an area settlement pond (number 14 in Figure 7-6-4), which will also be the settlement treatment facility for runoff generated from the Lurgi uncontaminated plant area. The pond will be designed to contain at least the 10-year, 24-hour event runoff from both sources (2,000,000 gallons). The water stored in this pond will allow settlement of sediment before being discharged to the natural drainage channel or lost to seepage or evaporation.

## 6.5 PONDS

Three types of ponds will be constructed and utilized at Tract C-a during the Lurgi Demonstration Project. Settling ponds will be used to provide sediment reduction treatment for disturbed area runoff before such water is released to the natural surface system. Evaporation/holding ponds will be used to contain water of suspect quality arising as runoff from ore stockpiles. Once the quality of such water is determined, it will be utilized in project operations or evaporated, as appropriate. Treatment ponds will be used for storage treatment of process water. Operation and design information on all ponds is presented in Table 7-6-1.

A. Settling Ponds - The operation of the RBOSC surface mine and Lurgi processing facility will cause a variety of different areas over the site to be disturbed. Administration facilities, equipment sheds, staging areas and haul roads will be constructed. Topsoil, and overburden material will be stockpiled. Precipitation on these various disturbed areas will evaporate, infiltrate or run off. The runoff will be collected in ponds and treated by either evaporation or settling prior to discharge under NPDES. All of these ponds are shown in the well and pond location plot plan, Figure 7-6-4. The contributing drainage areas to these ponds define geographic locations for a group of miscellaneous water flow systems, each containing one or more disturbed areas.

Because the only water inputs to these systems are precipitation events which are intermittent and vary in intensity, it is not possible to develop designs based on some continuous maximum flow. Instead, the systems must be designed to contain, treat and dispose of water from periodic inflows which are based on some precipitation recurrence criteria. The recurrence interval selection must be based on the degree of adverse impact that might be expected to occur if the design event were exceeded and sediment laden water spilled to the natural system.

For the systems which are disturbed only by haul roads, topsoil piles, overburden piles and drainage diversions, the only required treatment is sediment reduction via settling ponds. These ponds are sized to contain at least the

# Table 7-6-1

## OPERATIONAL AND DESIGN INFORMATION PERTAINING TO WATER CONTROL PONDS

| Pond | Type | Year Built | Disturbance Served | Drainage Area Acres | Design Event Yr/Hr | Sed. Vol. 3 Yr. AF | Design Flood Vol. AF | Spillway Design Evt. Yr/Hr | Spillway Design Peak cfs | Normal Evacuation Method |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Settling | 1982 | Topsoil & Overburden & Stockpiles | 142.0 | 10-24 | 4.4 | 3.3 | 100-24 | 29.1 | Pumped |
| | NOTE: An additional 6.2 AF of storage is available because of high spillway elevation | | | | | | | | | |
| 2 | Settling | 1981 | Pit Development Area | 34.2 | 10-24 | 0.86 | 2.3 | 25-24 | 17.7 | Decanted |
| 3 | Settling | 1981 | Pit Development Area | 7.8 | 10-24 | 0.2 | 0.5 | 25-24 | 4.4 | Siphoned or Pumped |
| 4 | Settling | 1981 | Topsoil Stockpile | 7.7 | 10-24 | 0.78 | 0.4 | 25-24 | 3.6 | Decanted |
| 5 | Settling | 1981 | Overburden Stockpile Haul Road | 41.6 | 10-24 | 2.4 | 2.0 | 25-24 | 13.2 | Decanted |
| 6 | Holding | 1981 | Haul Road, Facility Area | 40.3 | 100-24 | 4.98 | 3.7 | 100-24 | 20 | Pumped |
| | NOTE: Pond 6 also serves as dust control water reservoir - 3.44 AF maximum. | | | | | | | | | |
| 7 | Holding | 1981 | Shale Stockpile | 14.2 | 100-24 | 5.26 | 2.91 | 100-24 | 15.0 | Evaporation |
| | NOTE: Pond 7 has an additional 17.79 AF of capacity to reduce the probability of spilling to 0.01 during the ponds life. | | | | | | | | | |
| 8 | Holding | 1981 | Shale Stockpile | 8.0 | 100-24 | 3.36 | 1.5 | 100-6 | 8.7 | Evaporation |
| | NOTE: Pond 8 has an additional 2.54 AF of capacity to reduce the probability of spilling to 0.01 during the ponds life. | | | | | | | | | |
| 9 | Settling | 1981 | Haul Road | 0.95 | 10-24 | 0.3 | 0.07 | 25-24 | 4.9 | Siphoned or Pumped |
| 10 | Settling | 1981 | Haul Road | 3.67 | 10-24 | 0.6 | 0.14 | 25-24 | 4.7 | Siphoned or Pumped |
| 11 | Settling | 1981 | Topsoil Stockpile | 3.67 | 10-24 | 0.37 | 0.24 | 25-24 | 4.7 | Decanted |
| 12 | Settling | 1981 | Topsoil Stockpile | 1.37 | 10-24 | 0.137 | 0.09 | 25-24 | 4.7 | Siphoned or Pumped |
| 13 | Settling | 1981 | Process Facility Area Ext. Slope of Processed Shale Pile, Topsoil Piles, Haul Road | 24.6 | 10-24 | 16.5 | 11.32 | 100-24 | 197 | Decanted |
| 14 | Treatment | 1981 | LDP Waste Streams | 0 | N/A | N/A | N/A | N/A | N/A | Pumped |
| | NOTE: Pond 14 provides biological treatment for LDP waste streams effluent is pumped to Lurgi for reuse or Pond 15 for ho | | | | | | | | | |
| 15 | Holding | 1981 | LDP Waste Streams | 0 | N/A | N/A | N/A | 100-24 | 5 | Pumped |
| | NOTE: Pond 15 provides temporary on line storage for bio-treated water from Pond 14. | | | | | | | | | |
| 16 | Holding | 1981 | LDP Waste Streams | 0 | N/A | N/A | N/A | 100-24 | 5 | Pumped |
| | NOTE: Pond 16 provides temporary on line storage for excess quantities of high TDS waste water from the Lurgi | | | | | | | | | |
| 17 | Settling | 1982 | Mine Pit Sumps | 0 | N/A | N/A | N/A | 100-24 | 5 | Gravity Flow (Pumped Pond 19) |
| 18 | Settling | 1982 | Mine Pit Sumps | 0 | N/A | N/A | N/A | 100-24 | 5 | Gravity Flow (Pumped Pond 19) |
| 19 | Settling | 1982 | Mine Pit Sumps | 0 | N/A | N/A | N/A | 100-24 | 5 | Gravity Flow (Pumped Pond 19) |
| | NOTE: Ponds 17, 18 & 19 provide TSS removal for pit sump water prior to injection, discharge or system use. | | | | | | | | | |

runoff from all areas of the system for the 10-year, 24-hour storm per NPDES requirement.

In addition, water sumped from the surface mine to allow dry mining will also require treatment to reduce sediment loads. This water will be collected and treated in a series of settling ponds. That system has been designed to contain the expected peak sumping rates.

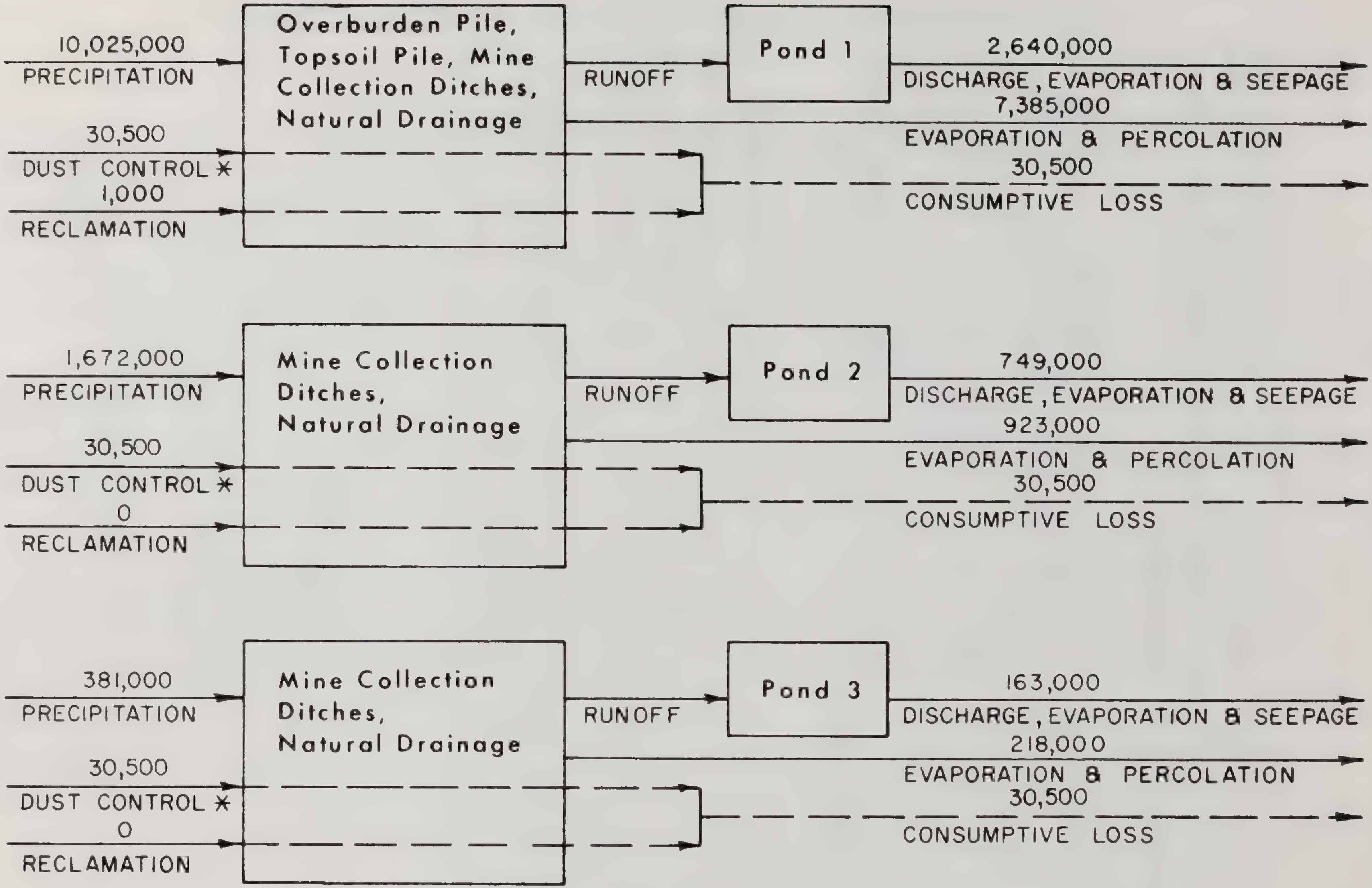
Because the disturbed areas in the systems may have little or no vegetative protection, they will be a possible source of fugitive dust. Therefore, water may be drawn from the mine system and applied to the various disturbed areas in these systems for dust control. However, all this water will be incorporated in the treated materials or consumed by evaporation and lost from the system. The only flow through the systems are source streams generated by precipitation.

1. Pond 2, 3, 9 and 10 - These four ponds provide settling treatment for water collected from mine and haul road collection ditches and undisturbed areas which naturally drain to the respective ponds. As sediment ponds, all have been designed to contain the runoff from the area in each contributing system generated by the 10-year, 24-hour precipitation events. Table 7-6-2 presents precipitation, evaporation and seepage, runoff and discharge volumes for each pond for the design storm. Water balances for Ponds 2, 3, 9 and 10 are presented in Figures 7-6-18 and 7-6-19 for the design and normal events respectively.

Table 7-6-2

HYDROLOGICAL CHARACTERISTICS
10-YEAR, 24-HOUR STORM EVENT
POND SYSTEMS 2, 3, 9 and 10

| Pond Number | Precipitation Inputs (Gallons) | Evaporation and Percolation (Gallons) | Runoff (Gallons) |
|---|---|---|---|
| 2 | 1,672,000 | 923,000 | 749,000 |
| 3 | 381,000 | 218,000 | 163,000 |
| 9 | 46,430 | 25,250 | 21,180 |
| 10 | 179,400 | 133,780 | 45,620 |




* NOTE: VALUES SHOWN ARE ESTIMATES FOR OPERATION PHASE, VALUES WILL BE SLIGHTLY DIFFERENT FOR OTHER PHASES.

**Figure 7-6-18 (1 of 4)**
**Miscellaneous Disturbed System Design Water Balances - Construction, Operation and Abandonment Phases**

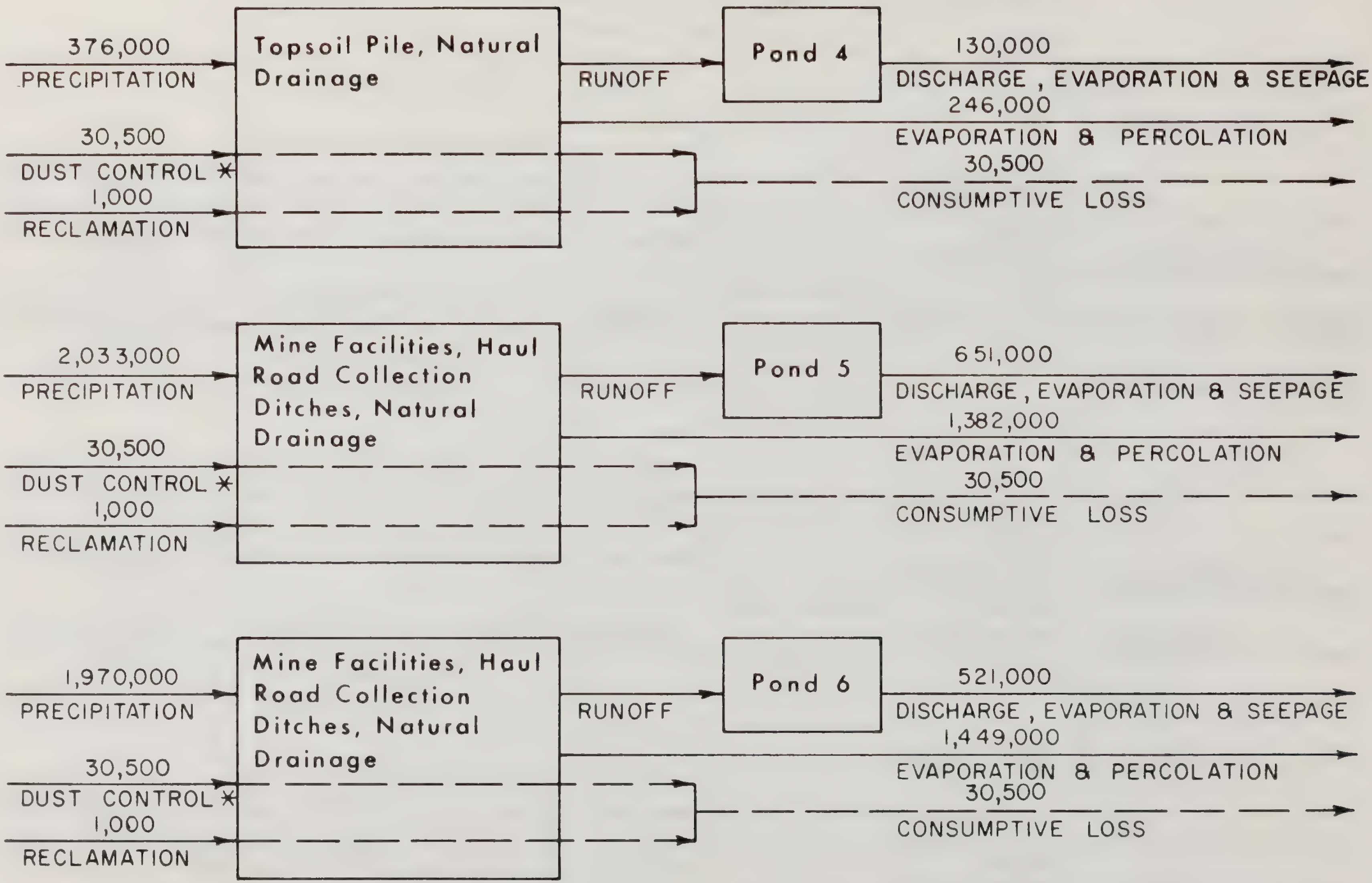



**Figure 7-6-18 (2 of 4)**
**Miscellaneous Disturbed Systems Design Water Balances**
**Construction, Operation and Abandonment Phases**

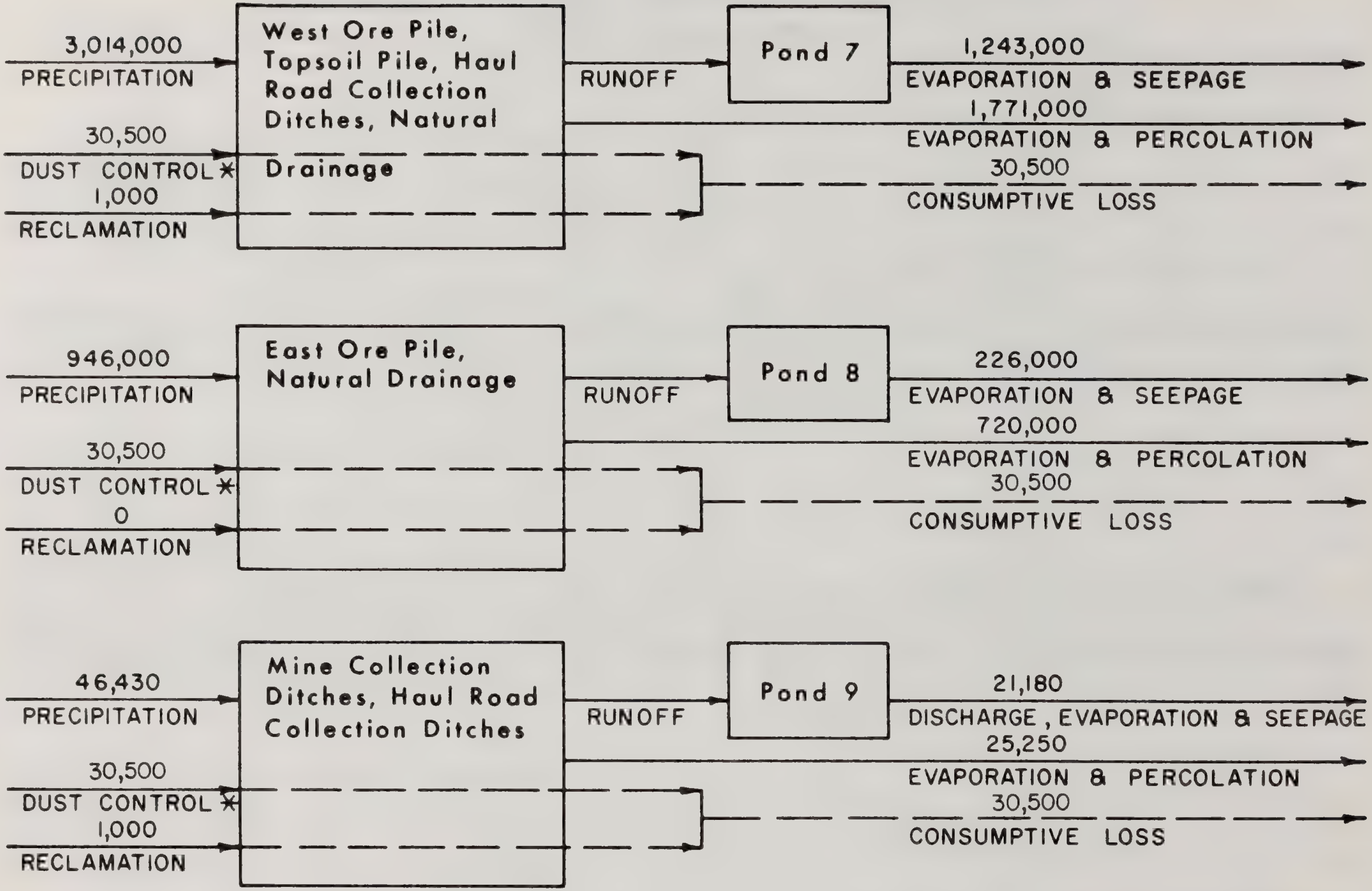



**Figure 7-6-18 (3 of 4)**
**Miscellaneous Disturbed Systems Design Water Balances - Construction, Operation and Abandonment Phases**

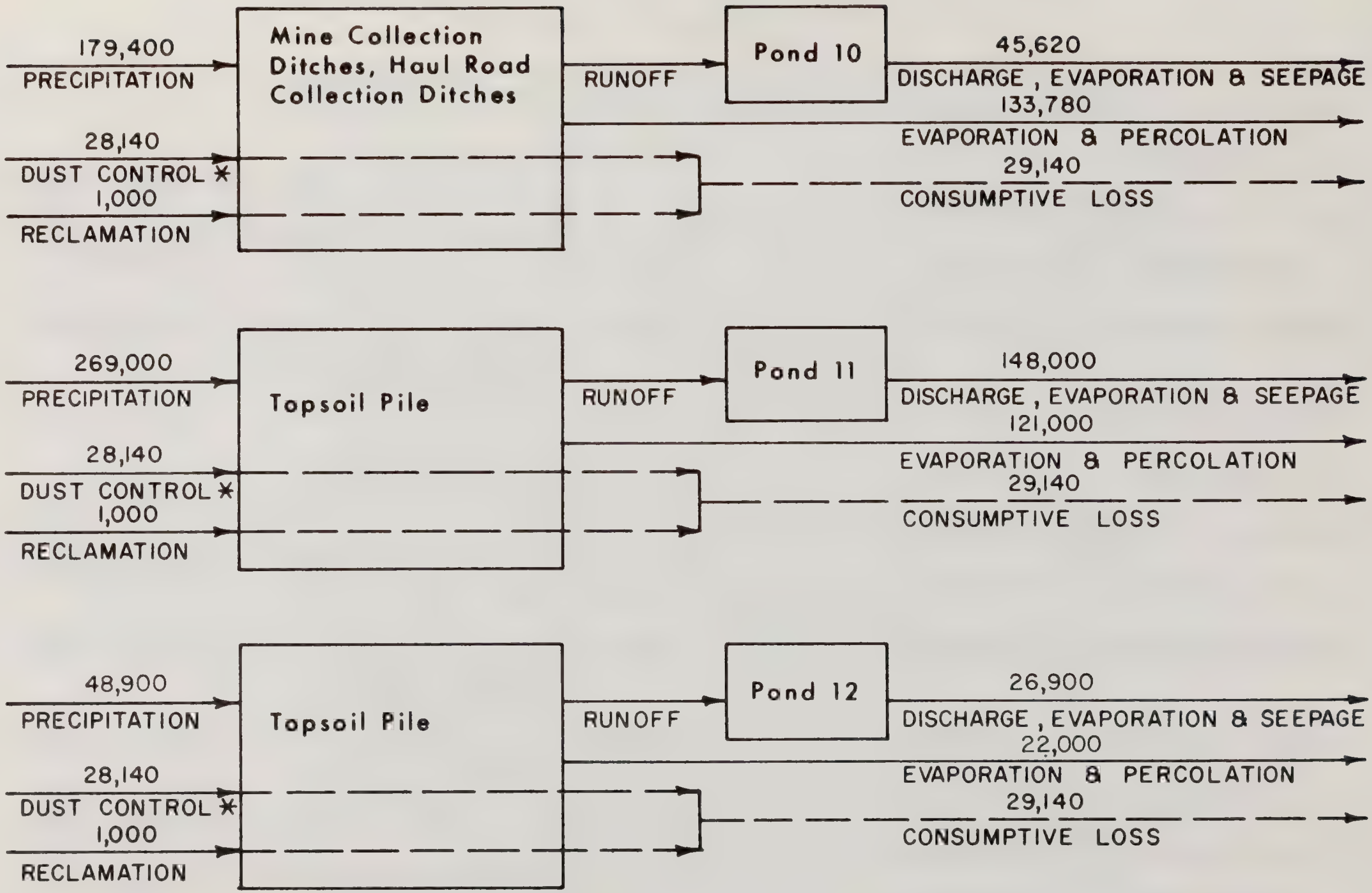
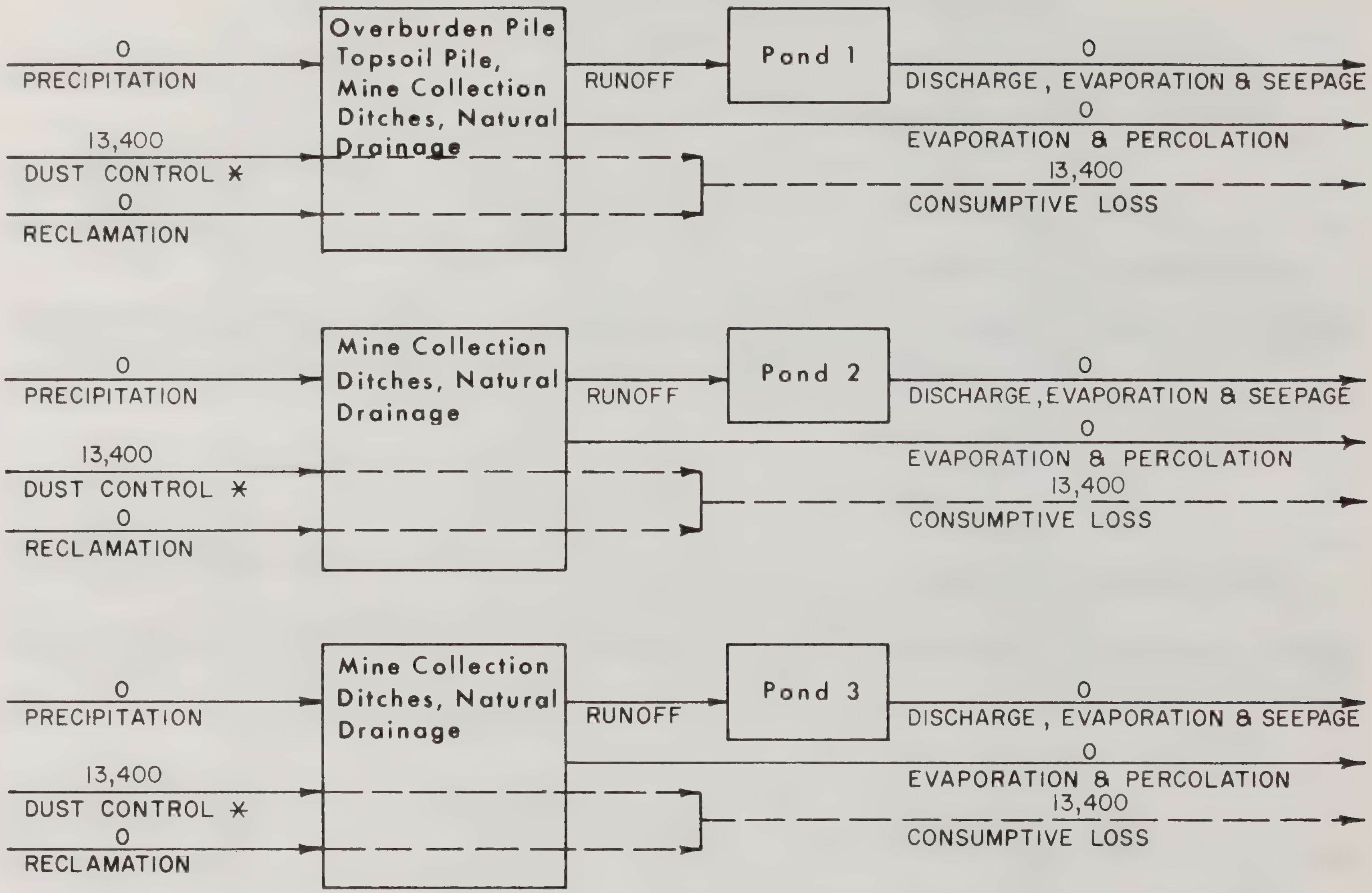



**Figure 7-6-18 (4 of 4)**
**Miscellaneous Disturbed System Design Water Balances - Construction, Operation and Abandonment Phases**




* NOTE: VALUES SHOWN ARE ESTIMATES FOR OPERATION PHASE - VALUES WILL BE SLIGHTLY DIFFERENT FOR OTHER PHASES.

**Figure 7-6-19 (1 of 4)**
**Miscellaneous Disturbed Systems Normal Water Balances - Construction, Operation and Abandonment Phases**

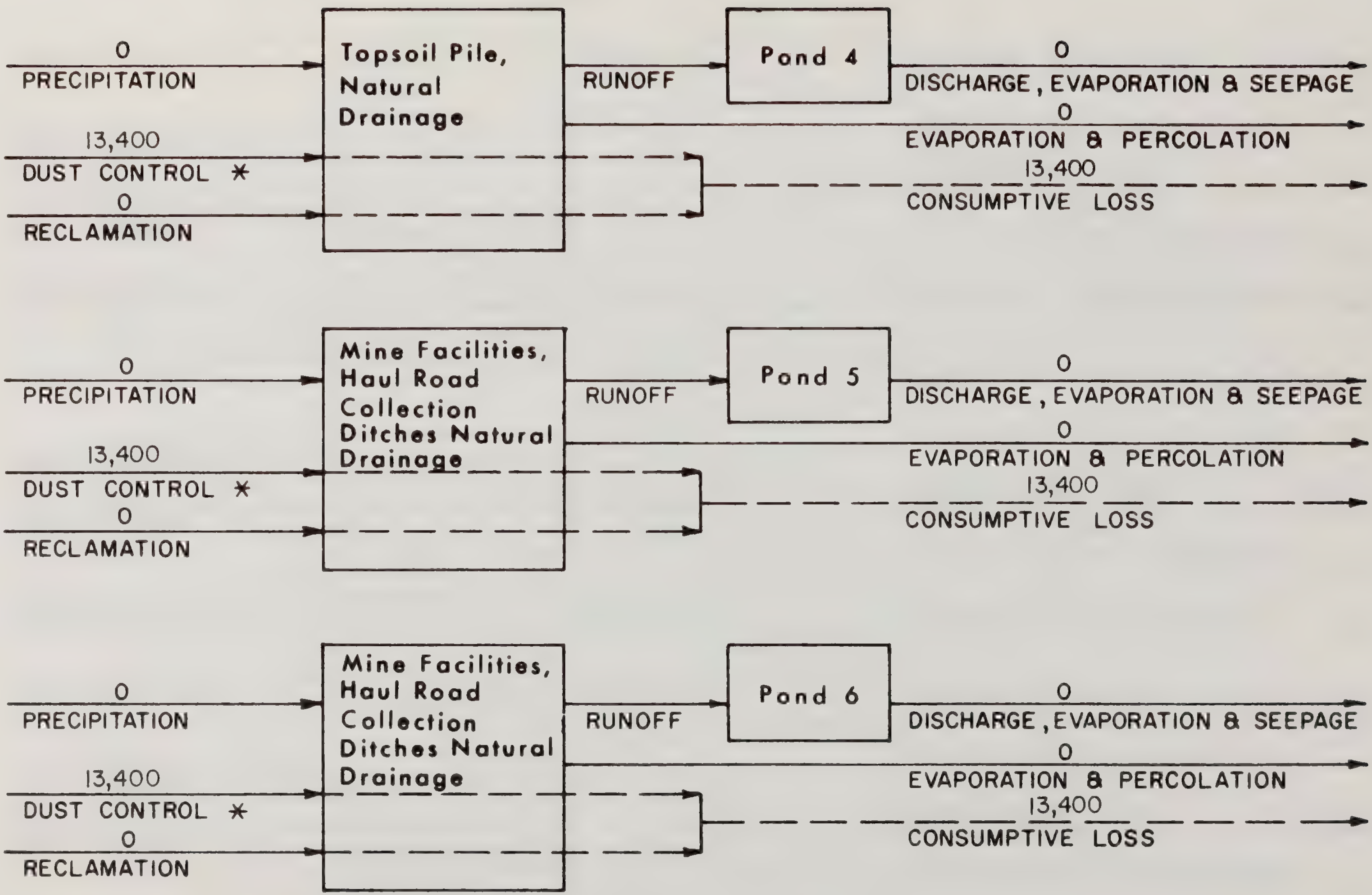



**Figure 7-6-19 (2 of 4)**
**Miscellaneous Disturbed Systems Normal Water Balances - Construction, Operation and Abandonment Phases**

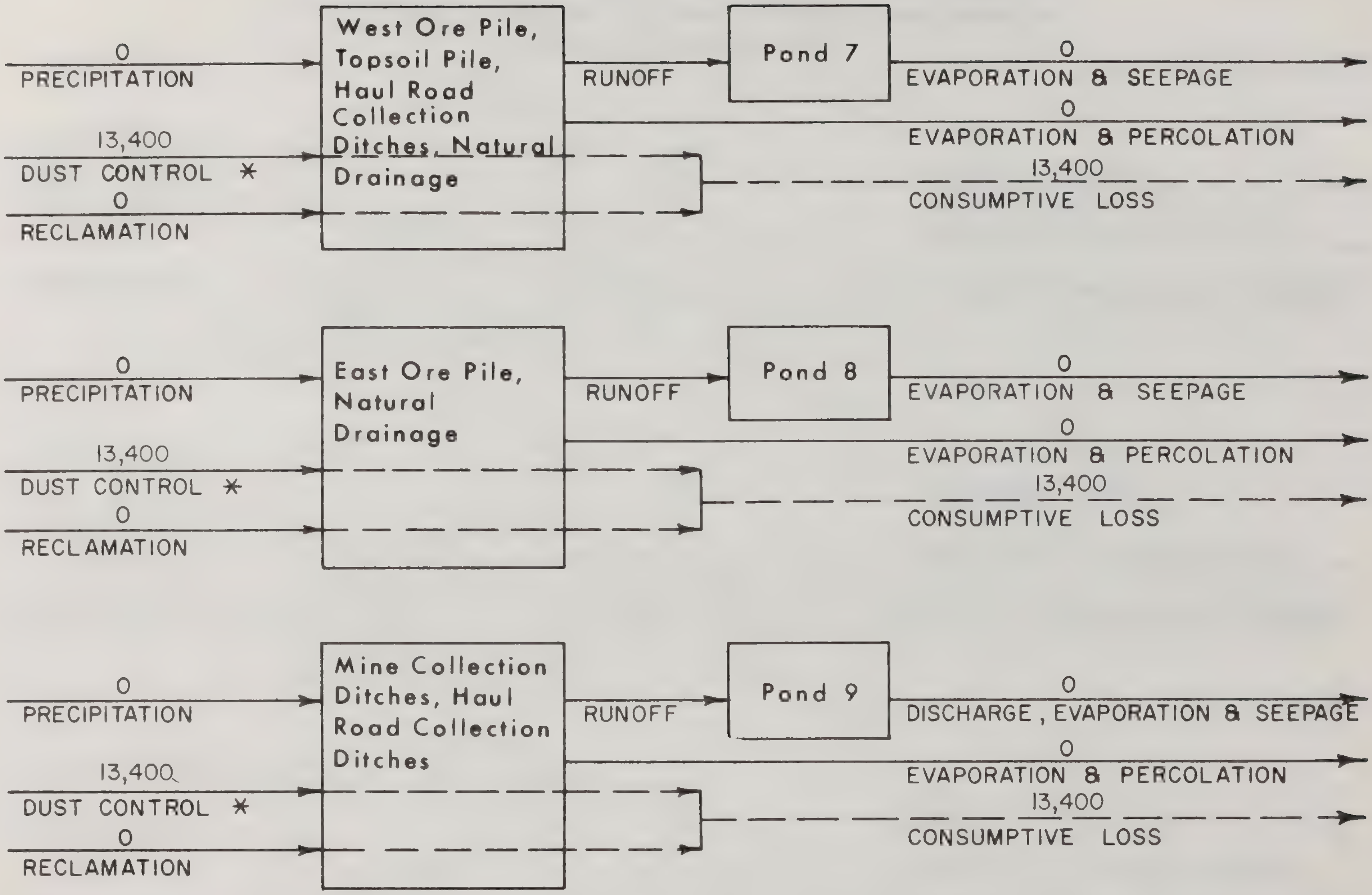



**Figure 7-6-19 (3 of 4)**
**Miscellaneous Disturbed Systems Normal Water Balances**
**Construction, Operation and Abandonment Phases**

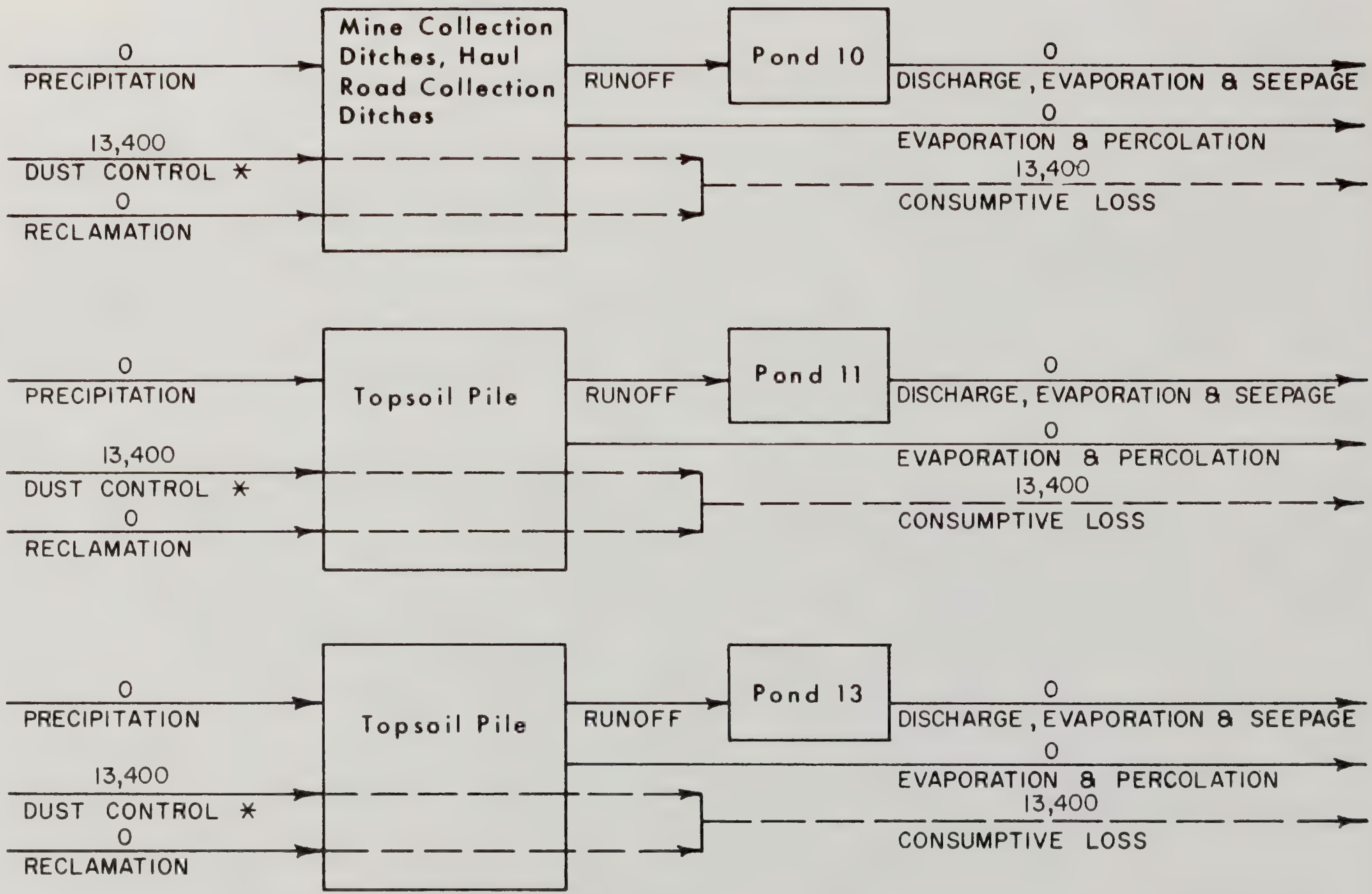



**Figure 7-6-19 (4 of 4)**
**Miscellaneous Disturbed Systems Normal Water Balances - Construction, Operation and Abandonment Phases**

2. Pond 4 - Pond 4 will collect runoff from a topsoil stockpile and any surface flow from upstream of the pile which runs off into the stockpile collection ditches. Pond 4 is designed to contain runoff from the 10-year, 24-hour precipitation event from all of the contributing areas. The design precipitation input volume is 376,000 gallons, which will generate 130,000 gallons of flow to Pond 4. This flow will evaporate or eventually be discharged to Dry Fork. The remaining 246,000 gallons will either seep into the soil or evaporate before reaching the pond. Water balances for this system are presented in Figures 7-6-18 and 7-6-19.

3. Pond 5 - Pond 5 will provide sediment removal treatment for runoff from an overburden stockpile and the haul road. It will also receive runoff from the undisturbed areas which naturally drain to the pond. The pond is designed to collect runoff from both areas for the 10-year, 24-hour storm. The design precipitation volume input is 2,033,000 gallons. This will produce 651,000 gallons of runoff into Pond 5, which will be evaporated or discharged to Dry Fork. The additional water is lost to evaporation or percolation before reaching the pond. The design and normal water balances for Pond 5 are presented in Figures 7-6-18 and 7-6-19, respectively.

4. Pond 6 - Pond 6 will serve as a treatment pond for runoff from portions of the mine facilities area, drainage from small undisturbed areas and water collected in ditches which drain the upper haul road. The pond will be built with enough storage to contain the 100-year, 24-hour runoff volume. In view of the central location of Pond 6, it will be convenient to supply this pond with a consistent water supply for dust control. Therefore, provisions will be made in the raw water distribution system to supply water to this pond on an as-required basis. Storage of water for dust control shall not exceed such a volume that the pond cannot contain the 10-year, 24-hour runoff event.

The 10-year, 24-hour design precipitation volume is 1,970,000 gallons, which will generate 521,000 gallons of runoff to the pond. The additional water will be lost to percolation or evaporation before reaching the pond. Design and normal water balances for the system are presented in Figures 7-6-18 and 7-6-19, respectively.

5. <u>Ponds 11 and 12</u> - Ponds 11 and 12 will collect runoff from topsoil stockpiles. Diversions will be constructed around each stockpile to direct upstream runoff around the piles and out of the system. Because of this, and because the ponds are constructed as trenches immediately downstream of the stockpiles, runoff from natural areas will be minimal. Both ponds will contain runoff from the 10-year, 24-hour storm. The design precipitation, evaporation and percolation, and runoff volumes are presented in Table 7-6-3. Design and normal water balances for each pond are presented in Figures 7-6-18 and 7-6-19, respectively.

TABLE 7-6-3

HYDROLOGIC CHARACTERISTICS
10-YEAR, 24-HOUR STORM EVENT
POND SYSTEMS 11, 12 and 13

| Pond Number | Precipitation Inputs (Gallons) | Evaporation and Percolation (Gallons) | Runoff (Gallons) |
|---|---|---|---|
| 11 | 269,000 | 121,000 | 148,000 |
| 12 | 48,900 | 22,000 | 26,900 |

6. <u>Pond 1</u> - Pond 1 will receive inflow from several natural and disturbed areas. Topsoil and overburden will be stored in separate areas of the Pond 1 drainage for use during reclamation. Runoff will be produced by these storage piles that will be diverted to the pond. In addition, collection ditches from around the mine, the topsoil stockpile area and the over burden stockpile area will discharge into Pond 1. The pond will also collect naturally draining runoff from a substantial undisturbed area.

Pond 1 is located in a drainage that flows naturally into the pit area. If water were to spill from the pond, or be discharged to the natural system by gravity drainage, it would flow into the collection ditch bordering the mine. This would create flow in the ditch in excess of the design flow and result in water flowing into the mine. For this reason, the pond will be designed for the 100-year, 24-hour storm input. The design precipitation volume is 10,025,000 gallons. Of this amount, 2,640,000 gallons run off to Pond 1 where it evaporates. The remaining water is lost to percolation or evaporation before reaching the pond. Design and normal water balances for the Pond 1 system are shown in Figures 7-6-18 and 7-7-19, respectively.

7. Pond 13 - Pond 13 will receive inflow from the processed shale disposal area and disturbed areas around the Lurgi plant site. This pond is described in Section 5, Chapter 2.

8. Ponds 17, 18 and 19 - Ponds 17, 18 and 19, shown in Figure 7-6-4, will provide settling treatment for water removed from the surface mine.

Pit water will unavoidably become contaminated with suspended solids as a result of the mining operation. Therefore this water will require treatment to reduce the suspended solids concentration to an acceptable level prior to process use, reinjection or discharge. A multicell lagoon clarification facility will provide such treatment. This system has been designed to operate at an average flow rate of 1,000 GPM and a peak flow rate of 5,000 GPM. It will be comprised of two primary 0.3-acre lagoons (Ponds 17 and 18) and one 1.5-acre secondary lagoon (Pond 19).

During normal base flow conditions, pit water will be pumped to one of the smaller lagoons while the other is being dewatered prior to sediment removal. The two ponds will be operated in parallel during high flow conditions. The small lagoons, with a 4:1 length to width ratio and a flow path of 250 feet, should be effective for removal of suspended particles 10 microns or larger in size, if outlet velocity is controlled to avoid discharging settled material.

Effluent from the small lagoon(s) will be piped to the large lagoon for secondary settling. This lagoon will be irregularly shaped to best fit local topography. Its stage will vary with storage demands. The lagoon will have a baffle inlet to control inflow and floating intakes for discharge pumps. The large lagoon will be required to remove a high percentage of particles in the range of 2 to 5 microns or larger, during high flow rates. Chemical flocculation could be required if there is a large percentage of extremely small particles.

Piping from the pit to the lagoons will also permit direct discharge into the large lagoon should the need arise. Ordinarily, discharge from the larger lagoon will be pumped to the process raw water treatment plant or reinjected. Discharge into Dry Fork may occasionally occur depending on discharge rates and supply demands. The quality of all discharges associated with waters originating from the pit or depressurization wells, would comply with the stipulations of the applicable NPDES and/or injection permits.

The treatment lagoons will be used during the operation phase with the water balance shown in Figure 7-6-10.

B. Holding/Evaporation Ponds - Those systems in which the ore stockpiles are located may contain water of unsuitable quality caused by chemical interaction with the shale. Because this water may be more objectionable than the sediment laden water, the treatment ponds are to be designed for a more extreme event. Therefore, for these ponds, two types of analyses were performed to determine the pond sizes. First, the pond volumes required to hold the 100-year, 24-hour storms were calculated, assuming initially dry ponds. These volumes were compared with the results of an analysis comparing joint monthly historic precipitation and stochastic evaporation amounts.

The model utilized for these analyses used a simple mass balance technique to compare monthly inflows and outflows at each pond. Pond inflow consisted of direct rainfall on the pond and basin runoff computed by the SCS curve number technique. Curve numbers were adjusted downward to reflect the soil evaporation and evapotranspiration that occurs during the month between rainfall events. The delay in runoff response from snow was not simulated as only seasonal effects were desired. Outflow from the pond for modeling purposes was assured to be the monthly pond evaporation amount; pond seepage was not calculated.

Assuming an initially dry pond and using 76 years of precipitation record from nearby Glenwood Springs and stochastically generated site monthly evaporation amounts, monthly changes in pond storage volumes over a five-year pond life were modeled. Seventy-two overlapping five-year periods were used. The peak storage values calculated for each of the five-year modeling periods were selected as a sample population, considered random and fit to a normal probability distribution. This distribution presented the probability of a certain storage volume being required once in a five-year period. These five-year risk values were converted to equivalent one-year risk levels for design purposes and the volume with 1% probability of occurrence in any one year for each pond was determined. The three-year sediment storage values were then added to the water storage volume requirements to determine final pond volumes.

In all cases, the seasonal analyses yielded larger required pond sizes and the ponds were designed for these volumes.

The quality of water collected in these ponds will be monitored. The water will be utilized in project operations such as dust control or evaporated as determined by water quality considerations.

1. Pond 7 - Pond 7 will catch and hold runoff from the west ore stockpile collection ditches and substantial undisturbed areas that naturally drain to the pond. Because this drainage includes water which has been in contact with ore, it will be of unknown quality. Therefore, the pond will be designed to store that volume of water that historic and stochastic records indicate has a 1% chance of occurrence in the system in any one year, and no discharge is planned. The storage volume will be greater than the volume of runoff expected from the 100-year, 24-hour storm, which is used to illustrate the design water balances in Figure 7-6-18. The 100-year, 24-hour input precipitation volume will be 3,014,000 gallons, which will generate 1,243,000 gallons of runoff. The additional water will be lost to percolation or evaporation before reaching the ponds. The quality of the collected water will be monitored and either utilized in project operations or evaporated, as appropriate. The design and normal water balances are shown in Figures 7-6-18 and 7-6-19, respectively.

2. Pond 8 - Pond 8 shown on Figure 7-6-4, will serve as the evaporation treatment pond for runoff originating from the east ore stockpile, collection ditches and minimal undisturbed areas. Because this flow originates on ore material, discharge to the natural stream is undesirable. Therefore, the

pond will be designed to store that volume of water that historic and stochastic records indicate has a 1% chance of occurrence in the system in any one year, and no discharge is planned. This storage is greater than that required for the runoff from the 100-year, 24-hour storm event, which is presented as the design storm used in the water balance presented in Figure 7-6-18. The 100-year, 24-hour input precipitation volume will be 946,000 gallons. This will produce a runoff volume of 226,000 gallons to the pond, with the additional water lost to percolation or evaporation. The quality of the collected water will be monitored and either utilized in project operations or evaporated, depending on the water quality. The design and normal water balances are shown on Figures 7-6-18 and 7-6-19, respectively.

C. Treatment and Storage Ponds

1. Pond 14 - Pond 14 will serve as a facultative lagoon to provide biological treatment to process and sanitary wastewater and to stripper condensate at the Lurgi processing facility. This pond is described in Section 4, Chapter 3 and Section 7, Chapter 7. The water balance for the lagoon is included in the Lurgi system water balance in Figure 7-6-2.

2. Pond 15 - Pond 15 will serve as a storage and holding pond for process and sanitary waste water and stripper condensate. It will have the capacity to store the normal flow from such sources for six months. This storage will be provided as a safety precaution, in the event that the treatment system malfunctions and does not produce effluent of the required quality. In such an event, facultative lagoon effluent will be stored in Pond 15 until the malfunction is corrected. The location of Pond 15 is shown in Figure 7-6-4. The water balance for Pond 15 is included in Figure 7-6-2. Additional information is presented in Section 4, Chapter 3.

3. Pond 16 - As discussed in Section 7, Chapter 6.3, Lurgi processing will generate a high TDS concentration waste stream which will normally be entirely consumed by processed shale moisturization. However when the Lurgi system is operating at extremely low capacity, the amount of processed shale produced will not be large enough to consume all high TDS water generated. Therefore, it will be necessary to store the high TDS water until the demand

for such water increases. Pond 16 will provide such storage. The pond has been designed to contain all high TDS water not utilized for processed shale moisturization under the worst conditions for one year. The location of this pond is presented in Figure 7-6-4. The water balance for Pond 15 is included in Figure 7-6-2. Additional information is presented in Section 4, Chapter 3.

## 6.6 DIVERSION AND COLLECTION DITCHES

Diversion ditches will be used to collect and channel storm runoff water from undisturbed areas upgradient from the mine and plant areas and convey it to the natural drainage stream. Collection ditches will be used to collect runoff from disturbed areas around the mine, haul roads, the Lurgi system and the processed shale disposal area and into retention ponds. These structures will be designed with consideration for the hydrologic properties of the areas contributing flow to the ditches and the hydraulic properties of the ditches themselves. The ditches will be designed to accommodate the peak flow associated with at least the 10-year, 24-hour storm event.

Nonerosive velocities will be maintained in these open channel ditches at all instances through the design event. Unlined channel maximum design velocity will vary from 2 to 5.5 feet per second depending upon the type of material through which the ditch would pass. Variation in channel configurations and hence, hydraulic properties, will typically permit maintenance of design capacity at or below erosive velocity. Where channel configuration alone cannot accomplish this, particularly in the case of relatively steep slopes, channel lining (riprap) has been specified to increase permissive velocity and retard actual velocity by friction loss. In some cases, the use of corrugated metal pipe (CMP) has been specified for short, extremely steep reaches. Energy dissipating rubble will be placed at all points where discharge velocities will be in excess of the receiving channel's erosive velocity limits.

## 6.7 MIS SYSTEM

RBOSC is currently operating an MIS mining demonstration project on Tract C-a which is, and will continue to be, operated as a closed system during the construction phase of the Lurgi Demostration Project. As with other closed systems on-tract, the MIS facility has associated water sources and requirements relating to the operation. Figure 7-6-20 is a plot plan of the MIS area. The following discussion summarizes the MIS water management program during the Lurgi Demonstration Project. The water balance is shown in Figure 7-6-21.

A. Lurgi Demonstration Project Construction Phase

1. System Generated Water Sources

a. Storm Runoff - When incident precipitation on the mine service area occurs above certain intensities, it will produce surface runoff. When such runoff occurs, it will be directed to the West Retention Pond. Runoff generated by precipitation falling on the process facilities will be directed to the East Retention Pond.

Surface runoff generated by precipitation incident to disturbed areas outside the MIS plant site will be collected in ditches and conveyed to the settling basins shown in Figure 7-6-20. Surface runoff from undisturbed areas above the MIS plant site will be collected in diversion ditches and rerouted into Corral Gulch.

b. Mine Seepage - In order to maintain the retort areas in a dry condition, drainage galleries have been installed in the retort area below the base of Upper Aquifer (Sub-E Level, Figure 1-1-2). During Lurgi Demonstration Project operation, ground water in the Upper Aquifer will be directed to these galleries by means of drain holes extending into the aquifer. This drainage will then be directed to the West Retention Pond for temporary storage prior to reinjection. Currently, the average ground water flow to the drainage galleries is about 1,100 GPM, or about 1,584,000 GPD. The design capacity of this system is 4,000 GPM, or 5,760,000 GPD.

c. Dewatering Wells - In order to minimize the flow of water into the mine seepage galleries, two dewatering wells are currently in use in the mine area and will probably continue operation during the Lurgi Demonstration

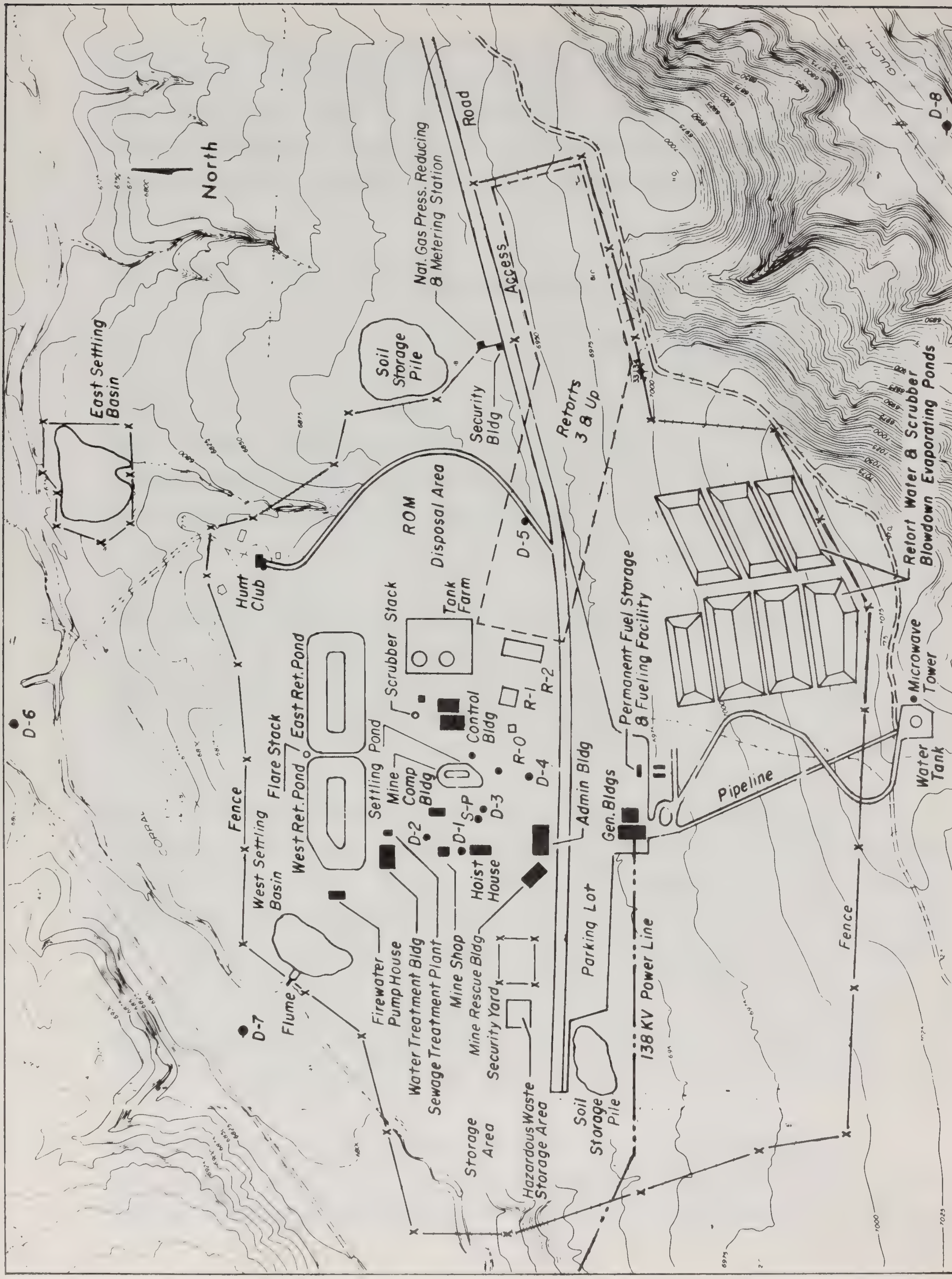



**Figure 7-6-20**
**MIS Area Plot Plan**

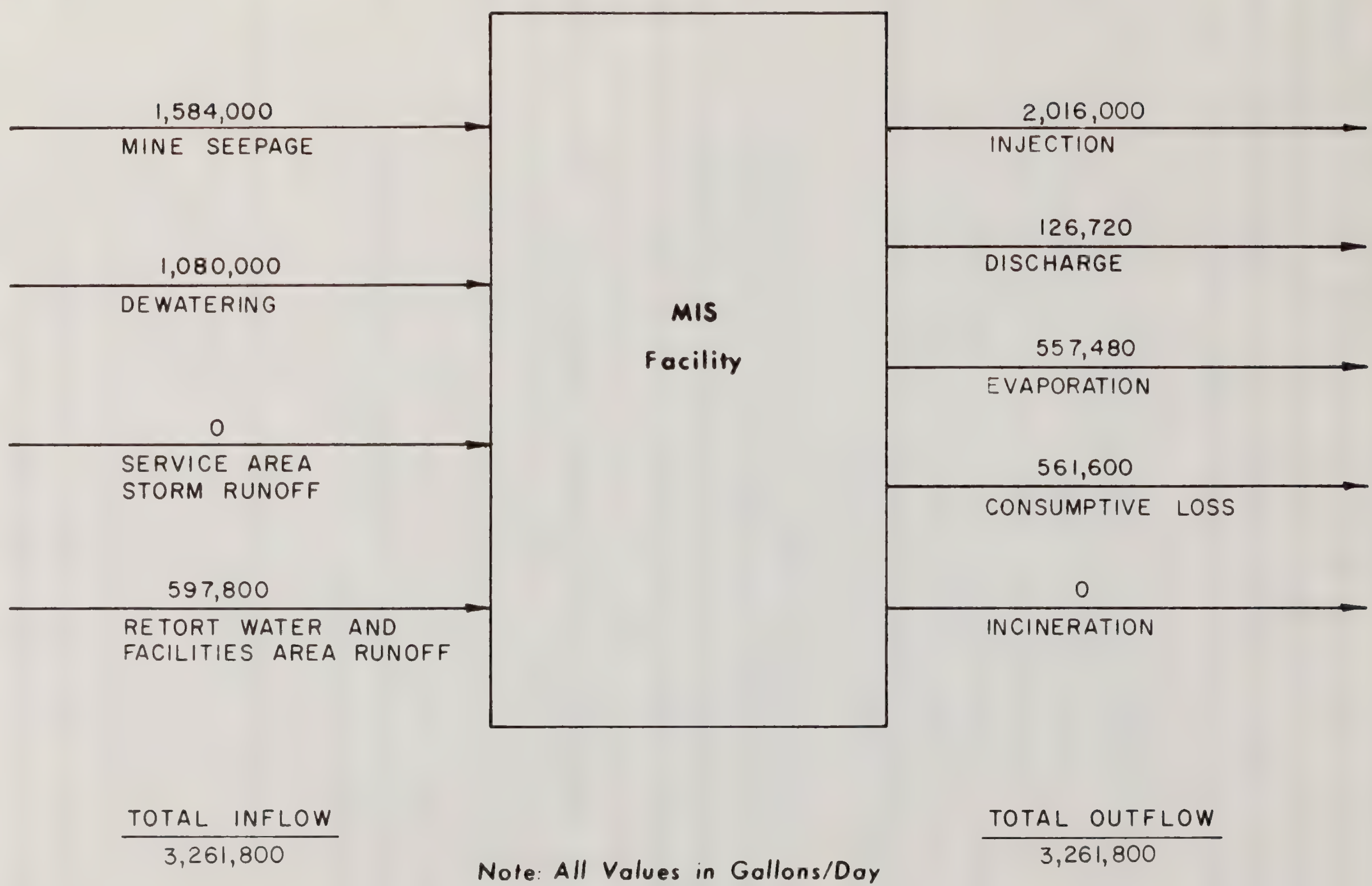



**Figure 7-6-21**
**Modified In Situ System Water Balance**
**LDP Construction Phase**

Project. These wells are screened in the Upper Aquifer, and pumped at an aggregate rate of about 750 GPM, or 1,080,000 GPD. The design capacity of this well system is 2,000 GPM, or 2,880,000 GPD. Water from these dewatering wells may be directed to the West Retention Pond, to the reinjection distribution system or to the Lurgi plant area for water supply.

d. Retort Water - The in situ processing of the oil shale releases water stored in the ore body. This water will be collected in the underground retort product separator, where it will be separated from the product stream. After separation, the retort water will be directed to the Retort Water Ponds.

e. Scrubber Blowdown - Blowdown from the scrubber will be directed to the Scrubber Blowdown Ponds.

f. Boiler Blowdown - Boiler blowdowns from the processing facility represent water streams in which the normal salts in the influent water have been concentrated. The design flow of this water source is 45 GPM, or 64,800 GPD. The boiler blowdown water will be directed to the East Retention Pond.

g. Water Treatment Plant Blowdown and Backwashes - A water treatment plant has been installed as a part of the MIS facility to supply potable water. The operation of this plant creates a waste stream of blowdown and backwash water in which the normal salts in the plant influent have been concentrated. This stream will be directed to the East Retention Pond until an NPDES permit is obtained for its discharge. The design flow of this water stream is 10 GPM, or 14,400 GPD.

h. Sewage Treatment Plant Outflow - A sewage treatment plant has been installed at the facility to treat domestic waste generated by the project work force. The design flow for this stream is 10 GPM, or 14,400 GPD. Presently this flow is directed to the East Retention Pond where it is lost by evaporation. During the Lurgi Demonstration Project operation, it is planned to retain the option of discharging this flow to the natural drainage system under an appropriate NPDES permit.

2. System Water Needs - The MIS system requires water for various purposes. This water will be supplied from the water sources described above. Sources and requirements have been matched on the basis of volume and quality constraints. The intent of the water source selections is to utilize sources for each need which represent the lowest quality water available which is a practical, suitable supply. This practice will have the effect of conserving the better-quality water at the facility, and will avoid the generation of more objectionable water streams which would be the by-product of extensive water treatment.

a. Process Water Use - Water will be required in the processing facility for various purposes. Such water will be supplied from the West Retention Pond. The design flow for this water need is 700 GPM, or 1,008,000 GPD. Current process water use averages about 350 GPM, or 504,000 GPD.

b. Potable Water Use - Water for the facility for potable and housekeeping uses is presently obtained from the West Retention Pond, treated by reverse osmosis and filtration, and distributed throughout the facility. The design flow for treated water is 10 GPM or 14,400 GPD. The generation of this treated stream requires an inflow of 20 GPM, or 28,800 GPD into the treatment plant. The remaining 10 GPM blowdown and backwash stream is directed to the East Retention Pond, as described in Part A.1.g above. This system will probably continue in operation during the Lurgi Demonstration Project.

c. Dust Abatement Water Use - During periods of dry weather, disturbed areas within the facility will require moisture to prevent the creation of objectionable quantities of dust. This water will be supplied primarily from the East Retention Pond, with augmentation from the West Retention Pond when the primary source is insufficient or unsuitable. This water use will be seasonal and intermittent, and thus normal flows are zero. A design flow of 50 GPM, or 72,000 GPD has been established. A water quality limit of 3500 mg/l total dissolved solids has been established by RBOSC for this use. The quality of the water from the primary source has been within this limit. Should dissolved solids concentrations in the East Retention Pond exceed this limit in the future, water from the secondary source would be utilized to bring the dust abatement water within the required water quality limit.

d. Fire Protection - An assured supply of water is presently maintained for fire fighting should the need arise and will also be available during the Lurgi Demonstration Project operation. This water drawn from the West Retention Pond, is stored in a 500,000 gallon water tank near the facility. The tank is filled by means of a water line having a capacity of 500 GPM. Water is available to the fire fighting system through a discharge line having a capacity of 750 GPM. Additional fire protection water will be available from the West Retention Pond. Water flow and pressure from this source will be provided by a fire-water pump which has a design capacity of 750 GPM into the fire fighting system.

3. System Water Outflows - Water obtained from the facility sources will be utilized to satisfy facility needs. The remainder of the water will be returned to the area hydrosphere, or, where the quality of the water is unsuitable, will be evaporated in specially-constructed evaporation ponds.

a. Injection - A system of six injection wells has been installed in the southern, eastern and northwestern portions of the tract. The purpose of these wells is to return excess water from the mine dewatering system to limit the extent of drawdowns in the aquifer resulting from the mine dewatering, and to protect area water supplies. This system will continue operation during Lurgi Demonstration Project for the same purpose, with the exception of the northwest well which is located in the proposed surface mine area. The design capacity of the system is 3,300 GPM, or 4,752,000 GPD. The average injection rate over the past year is about 1,400 GPM, or 2,016,000 GPD. Site monitoring data and computer simulations of aquifer response are confirming the effectiveness of the present MIS injection system.

b. Discharge to Surface Streams - The primary method of system discharge will be by injection into the Upper Aquifer. However, water production associated with mine drainage and shutdown of one or more injection wells occasionally has created flows larger than the capacity of the existing injection system. RBOSC has discharged this excess water in Corral Gulch at a point near the east tract boundary and may continue to do so during the Lurgi Demonstration Project operation. Water for this discharge will be taken from the West Retention Pond and discharged under the provisions of an NPDES permit. The design flow for this discharge is 2,800 GPM, or 4,032,000 GPD. The average discharge over the past year has been about 100 GPM, or 144,000 GPD. Permits also have been obtained for miscellaneous discharges such as well clearings. These discharges will occur only rarely, and volumes of water discharged will not be large. RBOSC also has applied for NPDES permits for contingency discharge in Stake Springs Draw, Box Elder Gulch and Duck Creek Draw. These permits would allow distribution of extreme surplus dewatering flows to the surface drainage system. Normally, no discharges would occur at these locations. An NPDES permit has been applied for discharge to Corral Gulch of the Sewage Treatment Plant effluent. The design flow of this discharge is 10 GPM, or 14,400 GPD. This stream will discharge near the eastern boundary of the tract.

c. Discharges By Evaporation - In order to protect the quality of area water resources, certain streams of marginal quality water will not be discharged directly to the tract surface drainage system, but will be evaporated in specially designed ponds. These streams are the retort water and the process scrubber blowdown. Additional retort water will be evaporated in the flue gas incinerator. Blowdown from the water treatment plant, the sewage treatment plant and process system boilers, as well as runoff from the process area will be directed to the East Retention Pond. Control of the water quantity in the East Retention Pond will be maintained by evaporation from an evaporation field. The design flow to this field is 13 GPM, or 18,720 GPD. In addition to these evaporative discharges, system evaporation losses will occur directly from the East Retention Pond and from the West Retention Pond. These losses are estimated to be 2 GPM, or 2,880 GPD for each pond on an annual basis.

B. Reclamation Phase - The plan for the recovery of the cone of depression for the MIS facility has been included in the calculations and discussions for the abandonment plan for the Lurgi facility. Section 2, Chapter 4 presents the results of the analyses for the recovery of the combined cone of depression. The water management calculations have been made for the scenario that MIS operations will be over prior to the Lurgi operation phase.

## 6.8 INTERACTIVE WATER MANAGEMENT SUMMARY

A. Construction Phase - During the construction phase, all water needs for the Lurgi Demonstration Project will be supplied by the water supply well system. Water from wells or mine sumps will normally flow to the surface mine system, the Lurgi processing system and the processed shale disposal system for construction, dust control and potable purposes, and to the various miscellaneous closed systems for dust control. When extremely dry conditions occur on the site for extended periods of time, additional water may be drawn from the wells to irrigate reclamation vegetation at various site locations.

The majority of the water drawn from the Upper Aquifer will be lost from the project system by evaporation or consumptive use. Only small volume streams of treated sanitary effluent from the surface mine system and the MIS facility will normally be discharged. A second waste stream, treated sanitary effluent from the Lurgi processing system, will flow to the shale disposal system where it will be consumed in dike construction.

Infrequently, precipitation events will occur over the site area. Runoff from all disturbed areas will be collected in settling ponds, which will built concurrently with other construction activities for sediment reduction treatment. When sediment loads are reduced to acceptable levels, this water will be discharged to the natural drainage system. Runoff from the MIS area will continue to be collected in the appropriate pond.

Water will be generated at the MIS facility by dewatering wells, removal of mine seepage water and release of water from raw shale during processing. A portion of this water will be utilized in oil shale retorting and the balance will be injected back into the Upper Aquifer to control the cone of depression resulting from mine dewatering, consumed, evaporated or discharged to Corral Gulch.

Figure 7-6-22 shows possible water flow paths and normal flow rate values for the construction phase.

B. Operation Phase - Water will be generated during the operation phase of the Lurgi Demonstration Project from water supply wells and from ground water flow into the surface mine. Flow into the surface mine will be removed from the mine and directed to a settling pond where it will be treated to reduce sediment loads. These two sources will be used to supply all Lurgi Demonstration Project demands during the operation phase. The water management plan for this Phase has been designed with enough flexibility that water required for any demand can be supplied by either source. These demands include operational and potable water for the Lurgi processing system and the processed shale disposal system, dust control water for the surface mine system and miscellaneous closed systems, and operational water for the surface mine system. When extremely dry conditions occur on-site for extended periods of time, water may be supplied from one or both sources for irrigation of reclamation vegetation at various site locations. Water supplied to the various systems will normally be lost by evaporation, seepage and consumptive use. The only normally occurring discharge will be treated sanitary effluent from the surface mine system and the MIS facility. However, to maintain flexibility in the operation, the option to discharge tertiary treated waste streams from the Lurgi processing facility will also be maintained.

Any surplus source water, usually from excess ground water flow into the mine, will be injected into the Upper Aquifer to contain the spread of the ground water depression cone in areas where significant hydrologic impacts will occur. It may be necessary to discharge some surplus mine water to Dry Fork under an NPDES permit.

Infrequently, precipitation events will occur over the site area, inputting additional water into the systems. Precipitation falling directly on the MIS and Lurgi processing facilities will be incorporated into the process streams. Runoff from precipitation falling directly on processed shale or raw shale ore will be collected and evaporated. All other runoff from disturbed areas will be collected in settling ponds for treatment to reduce

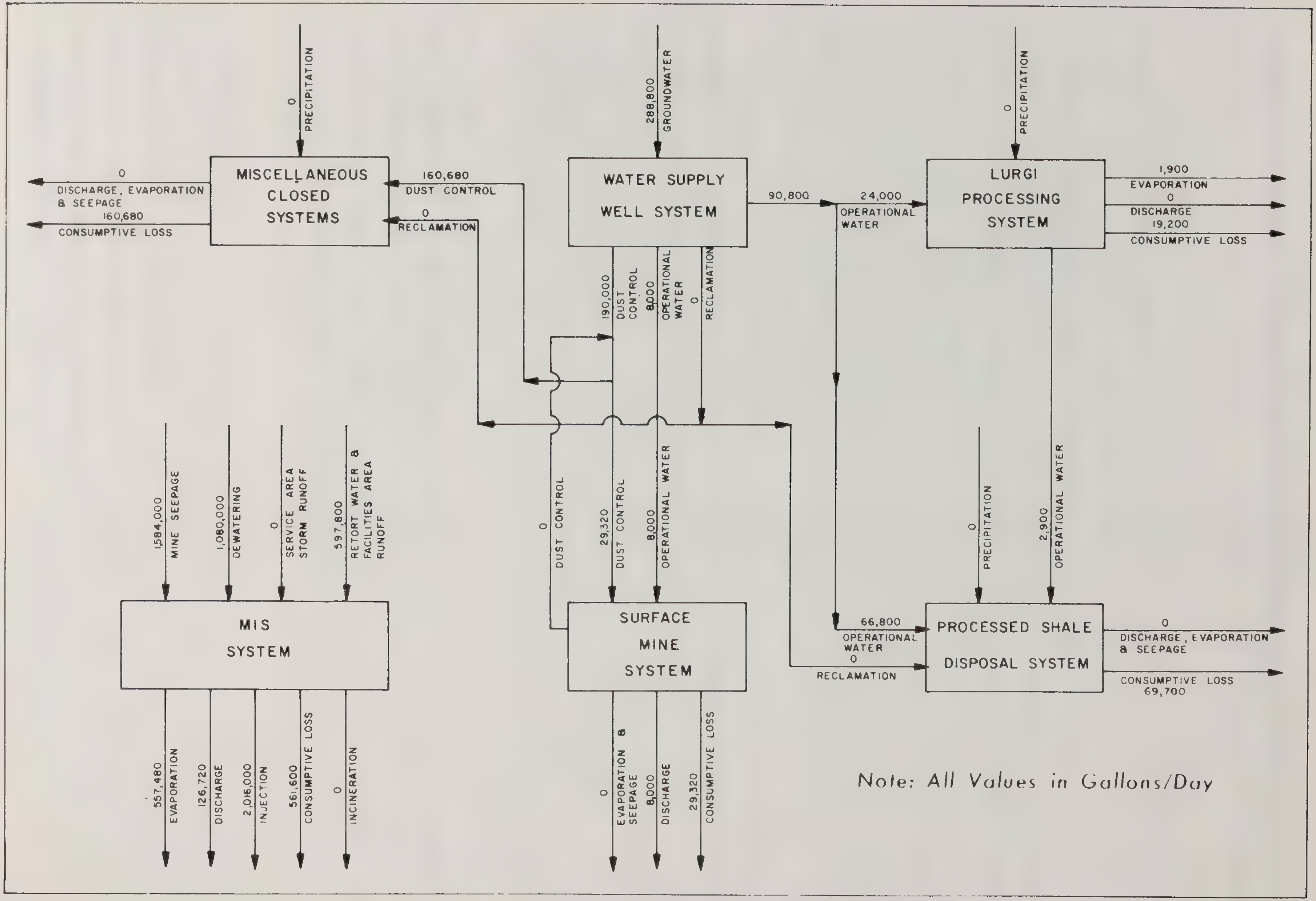



Figure 7-6-22
Summary Water Flow Diagram-Construction Phase

sediment loads and discharged to the natural drainage system. Runoff from undisturbed areas will be diverted around the operations to the natural stream.

Figure 7-6-23 shows possible water flow paths and normal flow rates for all systems during the Lurgi Demonstration Project operation phase.

C. Abandonment Phase - During the abandonment phase of the Lurgi Demonstration Project, all water needs will be supplied by the water supply well system. Water from wells will normally flow to the surface mine system and miscellaneous closed systems for dust control and to the surface mine system for housekeeping water. When extremely dry conditions occur on the site for extended periods of time, additional water may be drawn from the wells for irrigation of reclamation vegetation at various site locations. All water supplied to the systems, with the exception of treated sanitary effluent from the surface mine system and the MIS facility, will normally be lost to evaporation or consumptive use. The treated surface mine system sanitary effluent will normally be discharged to Dry Fork, and that from the MIS facility will be discharged to Corral Gulch.

Infrequently, precipitation events will occur over the site area. Until all disposed shale is reclaimed, runoff from precipitation falling directly on such shale will be collected and evaporated. Runoff from other disturbed site areas will be collected, treated to reduce sediment loads and discharged to the natural system. Such collection, treatment and discharge will continue at each disturbed area until final reclamation of that area is achieved.

Figure 7-6-24 shows possible flow paths and normal flow rates during the Lurgi Demonstration Project abandonment phase.

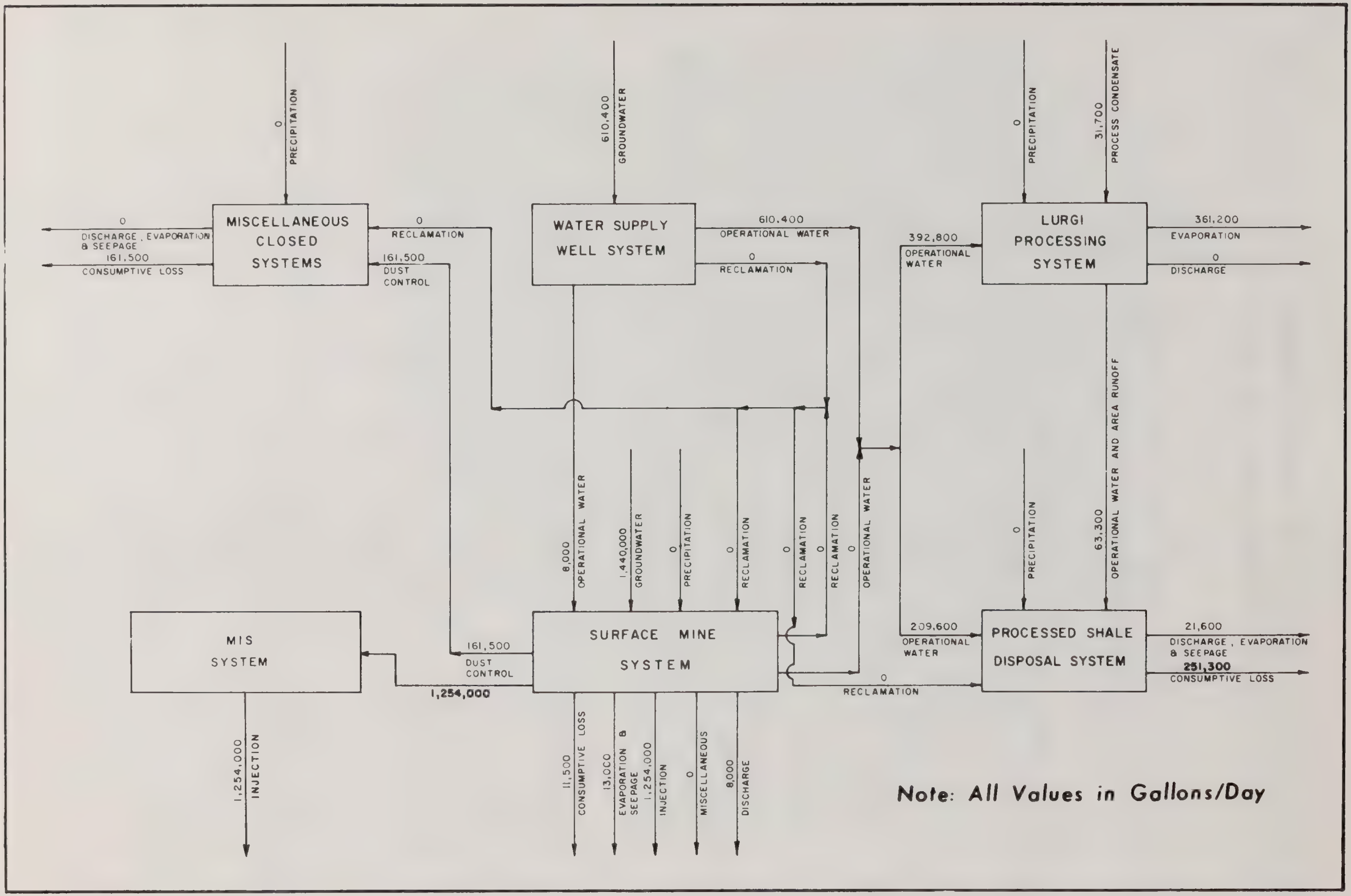
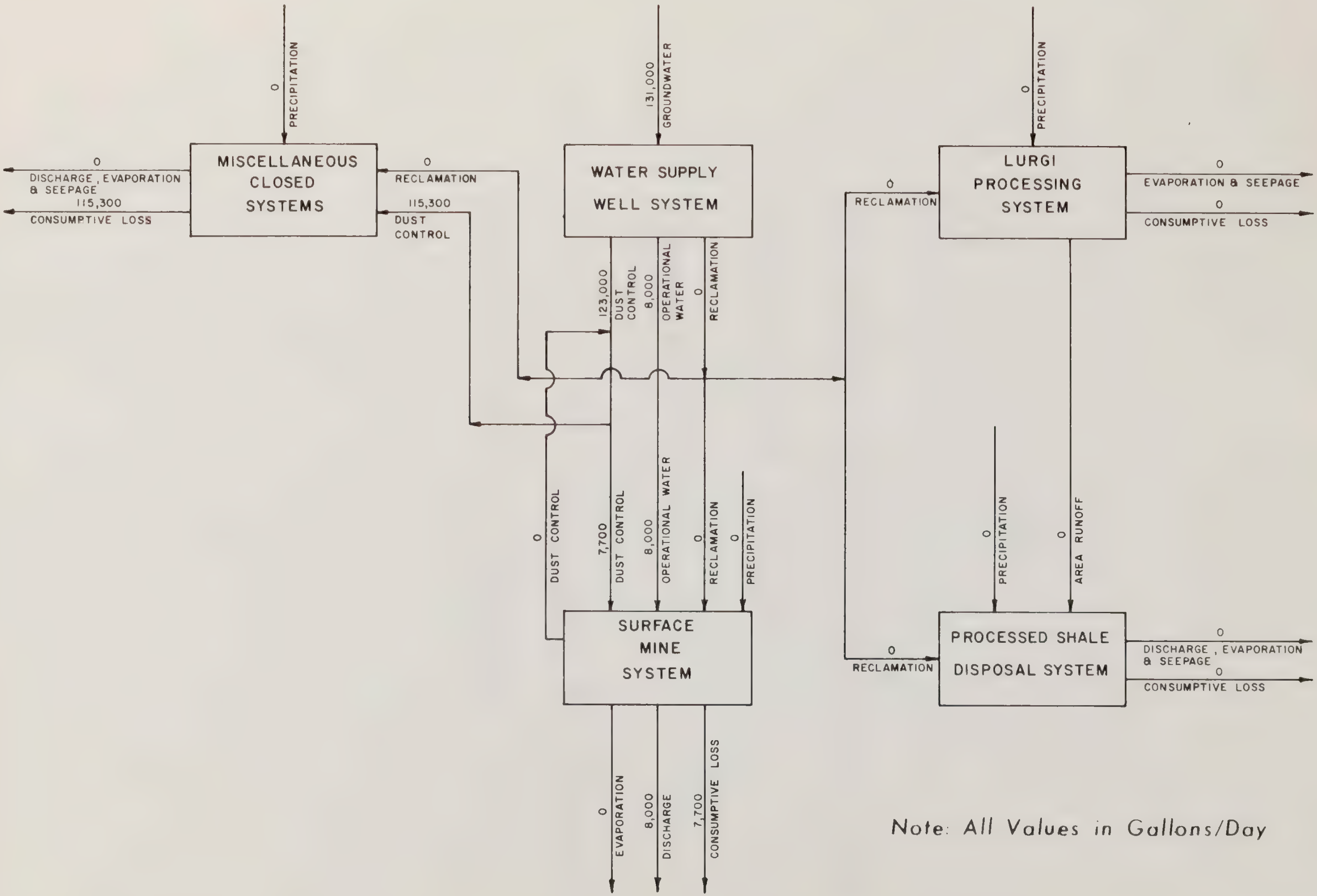



Figure 7-6-23
Summary Water Flow Diagram - Operation Phase




*Note: All Values in Gallons/Day*

**Figure 7-6-24**
**Summary Water Flow Diagram - Abandonment Phase**

# Section 7

# ENVIRONMENTAL PROTECTION, HEALTH and SAFETY

## Chapter 7

## Oil and HAZARDOUS MATERIAL and WASTE CONTROL

CHAPTER 7

# OIL AND HAZARDOUS MATERIAL AND WASTE CONTROL

The plan for control of oil and hazardous material and wastes has been formulated recognizing that the best control plan is to prevent spills through proper design of storage, handling and transporting facilities, and by designing process equipment to eliminate or reduce accumulation of hazardous wastes. The plan described herein has been developed to further reduce these hazards. A Spill Contingency and Hazardous Waste Management Plan will be implemented during all phases of the Lurgi Demonstration Project.

## 7.1 APPLICABLE REGULATIONS

Facility design and spill contingency plans have been developed in conformance with the applicable laws, regulations, codes and standards. Some of the principal regulations are listed below:

- U.S. Department of the Interior, Oil Shale Lease Tract C-a, February 5, 1974
- Title 40, Chapter 1, Part 165, Federal Register (FR) 39, No. 85, May 1, 1974, Regulations for the Acceptance of Certain Pesticides and Recommended Procedures for the Disposal and Storage of Pesticides and Pesticide Containers
- Title 49, Parts 171 through 179, FR 45, No. 101, May 20, 1980, Transport of Hazardous Wastes and Hazardous Substances
- Title 40, Part 112, FR 45, No. 99, May 20, 1980, Oil Pollution Prevention (Nontransportation-Related Onshore and Offshore Facilities)
- Title 40, Parts 260 through 265, Section 3010; FR Vol. 45, No. 98, May 19, 1980, Hazardous Waste Management System (Note: Mining Activities are currently exempt from regulation under the Solid Waste Management Act Amendments of 1980. However, process waste streams will be handled in a manner acceptable under 40 CFR 265).

- Title 40, Chapter V, Part 1510, FR Vol. 40, No. 28, February 10, 1980, National Oil and Hazardous Substance Pollution Contingency Plan
- PL 95-217, Clean Water Act of 1977
- Colorado Revised Statutes (1973) 25-8-601 - Requirements for Notifying Colorado Department of Health (Water Quality Control Division) of spillage
- Colorado Senate Bill No. 390, Water Quality Control
- Colorado Health Department - Procedures and Directory for Reporting Spills of Oil and Hazardous Materials

## 7.2 OIL AND HAZARDOUS MATERIALS AND WASTES INVENTORY

Safe handling and storage and the effective cleanup of accidental spills of oil, hazardous materials or wastes requires adequate information on the source, location, chemical characteristics, quantity and potential hazards of each of these materials. In order to obtain this information, RBOSC has conducted an on-site inventory of all MIS-related petroleum product storage facilities and potential spill points, all process waste streams and all discarded materials. Similar information has been generated for the Lurgi Demonstration Project.

Materials of concern are divided into the following four categories:

- Oil and other petroleum products
- Solvents, chemicals, poisons, explosives and other potentially hazardous materials
- Process waste streams
- Discarded hazardous materials

The source (i.e., produced as a product or by-product, purchased or discarded as a waste) and quantity of these potentially hazardous substances accumulated over a 90-day period is identified in the inventory. The inventory describes the physical location of the material, the method of storage or disposal and the names of foreman/superintendent in charge of the activity which produces, purchases, or discards the material in question.

As appropriate and available, data sheets on safety materials are obtained or written which describe the chemical characteristics of the inventoried materials, dangers associated with handling of these materials and precautions to be taken in storing or disposing of these materials.

All inventory information, safety data and disposal restrictions will be incorporated into the Spill Contingency and Hazardous Waste Management Plan (discussed in Part 7.3).

Produced wastes or discarded materials suspected of being hazardous according to criteria set forth in the May 19, 1980 Federal Register - Hazardous Waste Management System - will be tested prior to disposal. All wastes which meet these criteria will be handled and disposed of in a manner consistent with requirements in 40 CFR Part 262 and/or 264. Information on the chemical characteristics of these wastes will be added to the inventory.

Sampling and analysis of waste streams and discarded materials will be conducted according to procedures described in Test Methods for Evaluating Solid Wastes (EPA 1980). Representative sampling techniques as per 40 CFR 261, Appendix I will be followed. Chain of Custody procedures for sample identification, verification, shipping and storage will be followed. EPA protocols for testing (40 CFR Part 261, Subpart C) will be used.

## 7.3 SPILL CONTINGENCY AND HAZARDOUS WASTE MANAGEMENT PLAN

The following is a summary of the Spill Contingency and Hazardous Waste Management Plan which is being developed to ensure safe storage, handling and disposal of oil and hazardous materials and wastes and to insure the proper containment and cleanup of spills of these materials. The detailed plan is kept on site for use by tract personnel, and is available for review on the tract.

The plan described herein includes procedures for the following: sampling and analysis of waste streams and discarded materials; proper storage, treatment and disposal of oil and hazardous materials and wastes; contingency actions to be taken in case of accidental spills or discharges of oil or hazardous materials or wastes; notifications; record keeping; training;

inspections; monitoring; and proper closure of oil or hazardous materials or wastes storage areas.

A. Storage and Handling

1. Oil and Other Petroleum Products - The facilities for storage of product oil and other produced hydrocarbons, diesel fuel and any other petroleum products will be designed to minimize the possibility of spillage. The layout and construction of the tanks, valves, piping and appurtenances will follow the requirements of the Tract C-a lease and recommendations and standards of the American Petroleum Institute (API).

Tanks will be enclosed by dikes designed to form spill-containment basins. Interior surfaces of the diked areas will be impermeable. The diked areas will be:

a) one-hundred ten (110) percent of the largest tank plus displacement of all other tanks in the compound below the dike height or liquid level; plus

b) a volume sufficient for maximum trapped precipitation and run-off which might be impounded at the time of a spill. The earthen dike will have a flat surface three feet wide on top of the dike.

Each area will be designed for drainage away from the tanks into a collection basin. The drainage from these diked areas will enter the process facility storm drainage system and pass through an oil separator. Any oil present will be removed from the water by the CPI oil separator and the DAF unit and returned to the oil handling system. The reclaimed water, after biological and physicochemical treatment, will be used to cool and moisturize processed shale.

Catchments will be constructed in any natural drainageways immediately down gradient from the storage facilities so that any spill outside of the containment facilities can easily be controlled before it reaches a water course.

2. Solvents, Chemicals, Poisons, Explosives and Other Potential Hazardous Materials - In most cases, quantities of these materials on site will be small. Caution will be exercised, however, to prevent the storage of incompatible materials in close proximity to each other or the storage of hazardous substances near work areas. As much as possible, such substances will be stored in the "Hazardous Materials Storage Area" located near the MIS facility immediately adjacent to the west of the receiving yard (Figure 7-6-20). This area has been specially prepared to contain spills, is sufficiently remote from human activity to minimize hazards and is fenced for security. The area is 100' x 100' with 6 inches of impervious fill (clay) and 2 inches of gravel. It is surrounded by a 4' high 3-strand barbed wire fence. Explosives will be stored in specially constructed areas according to applicable State and Federal regulations as described in Section 6, Chapter 8.

The Hazardous Materials Storage Area will be inspected daily to detect leaks, spills or other problems. Upon detection, appropriate steps will be taken to contain and clean up the spill (See Part 7.4 below). Since the area is diked and lined with an impermeable barrier, no contamination of soil or groundwater is expected.

Insecticides, rodenticides and herbicides are often used on construction sites to protect health and safety of employees, maintain a good working environment and reduce maintenance and fire hazards. Rodents are often attracted to construction sites, necessitating the use of rodenticides. Herbicides, rodenticides and pesticides are not contemplated for general use on the project, however, and their use will require prior approval of the OSO. Clearance for use of many of these chemicals is also required by stringent Federal, State and local regulations.

If the need for use of herbicides, rodenticides or pesticides should arise, an awareness of the need to adhere to recommended dosages, proper type of application equipment, proper time of application and recommended procedures for cleaning of application equipment and safe disposal of these chemicals will be instilled in employees and contractors engaged in these activities. The disposal and storage of pesticides and pesticide containers will conform to recommendations set forth in applicable Federal, State and local laws and regulations, and the procedures promulgated by Environmental Protection Agency.

3. Process Waste Streams - Data accumulated to date indicate that process water produced by the Lurgi process is not hazardous according to the criteria set forth in 40 CFR Part 261 - Identification and Listing of Hazardous Waste. Furthermore, mining activities have recently been exempted from regulation under the Resource Conservation and Recovery Act by the 1980 Amendments to the Solid Waste Management Act. However, in view of concerns over possible contaminants in these waste streams, RBOSC is planning to treat or contain and evaporate all potentially hazardous waste streams from the Lurgi process. These treatment/containment/storage techniques are described in Section 7, Chapter 6.

RBOSC will thoroughly test the chemical characteristics of these waste streams before and after treatment. Tests described in 40 CFR 261 will also be carried out to determine if these streams are defined as hazardous under RCRA. Storage and treatment areas will be monitored to detect escape of these fluids from containment structures.

Process waste streams will be contained, treated and stored in a manner consistent with the degree of hazard they present and existing applicable regulatory requirements.

B. Discovery and Containment of Spills

1. On Site Facilities - The detection and prevention of leaks, overflows and miscellaneous spillage from tanks, storage vessels and impoundments will be ensured by frequent inspections and regular maintenance. To the extent practical, automatic controls that will operate in a fail-safe manner will be installed on all units, thereby minimizing dependence on the human element. Indicating, recording and controlling devices which will monitor pressures, temperatures and flow rates will be integrated with all processing equipment. In addition, alarms and shutdown systems will be used to warn of unusual

process conditions and to shut down operations before equipment failures can occur. Visual inspection of all equipment will be on a routinely scheduled basis.

a. Emergency Coordinator - An Emergency Coordinator will be responsible for coordinating all emergency response measures. Persons authorized to act as Emergency Coordinator will be identified and a listing of their names and addresses will be clearly posted in a conspicuous place. These individuals will be on 24-hour call to respond to spill emergencies. The duties of the Emergency Coordinator are clearly described in the detailed Spill Contingency and Hazardous Waste Management Plan kept on tract. The Emergency Coordinator must be thoroughly familiar with all aspects of the facilities contingency plan, all operations and activities at the facility, the location and characteristics of oil and hazardous materials and wastes, the location of all pertinent records within the facility, and the facility layout. The Emergency Coordinator will have the authority to commit the resources needed to carry out the contingency plan.

b. Notification - When a spill is observed, the Emergency Coordinator will immediately set in motion alerting actions and reporting procedures (Figure 7-7-1).

Federal and Colorado regulations require immediate reporting of spills that enter streams or could pollute either surface or ground water. Once the Emergency Coordinator has confirmed the occurrence of a reported spill and has initiated action to control the spill, the following agencies will be notified:

- Oil Shale Office, U. S. Geological Survey, Grand Junction, Colorado
- Region VIII, Office of EPA, Denver, Colorado
- Colorado Department of Health, Denver, Colorado
- Bureau of Land Management, Craig, Colorado

Oil spill and hazardous waste management regulations define procedures for external notification. Internal reporting can vary, however, with the size of spill, the nature of spilled material and significance of response

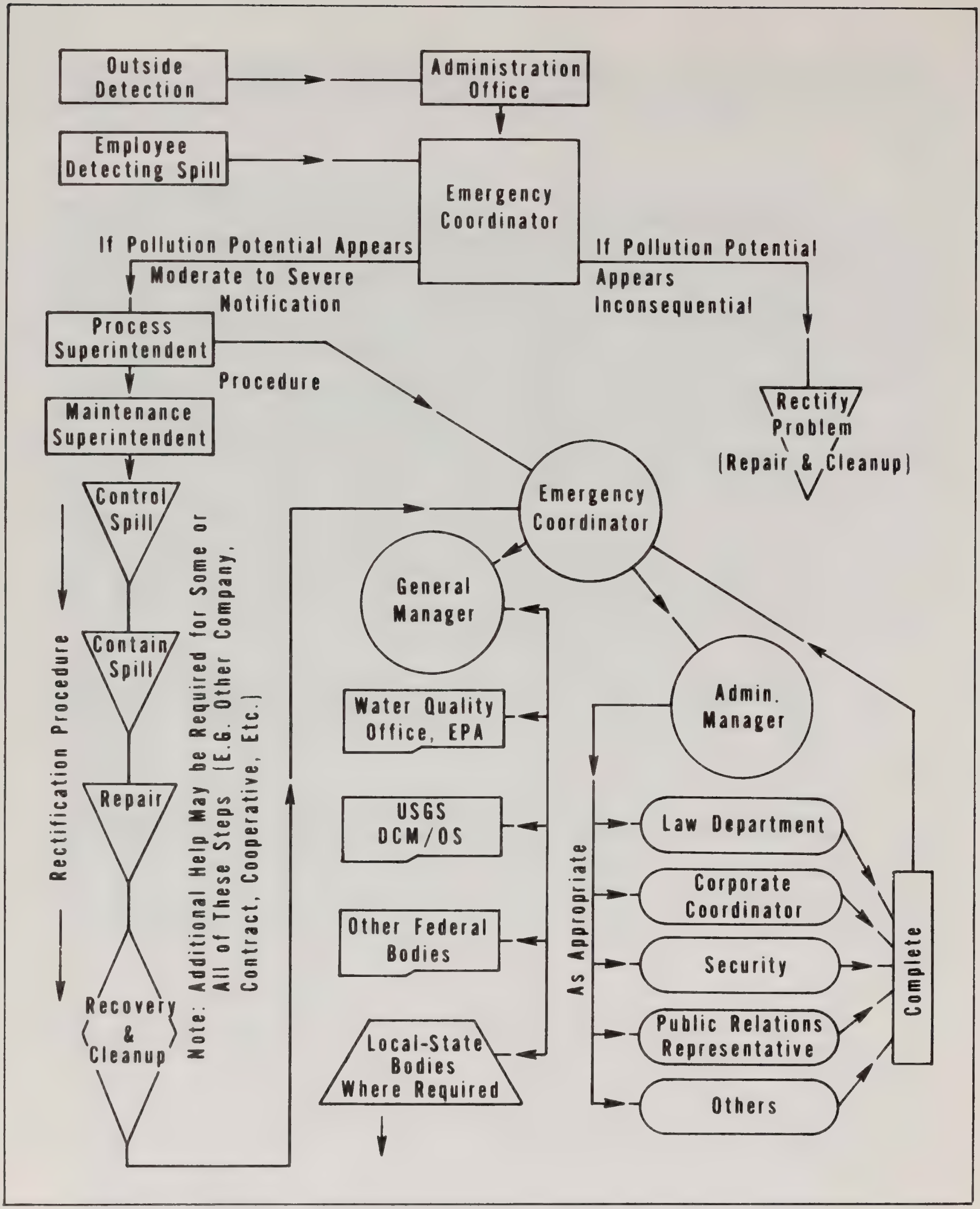



Figure 7-7-1
Alerting and Action Procedures
For Oil and Hazardous Material and Waste Spills

requirements. Due to the number of people to be notified and the need for simultaneous initiation of response action by local supervisors, delegation of alerting duties by the Emergency Coordinator is required. This progressive alerting and action procedure is outlined on Figure 7-7-1.

c. Information Gathering - Certain information pertinent to planning the response to a spill occurrence must be gathered from the reporting source by the Emergency Coordinator. This information generally includes:

- Name and telephone number of reporter
- The extent of injuries, if any
- Description of material spilled
- Possible hazards to human health
- The time the spill started or was first observed
- The location where the spill occurred and the present estimated rate of spreading
- An estimate of the amount spilled or rate of release if the spill is continuing
- The environmental conditions, including temperature and wind direction and speed
- A description of the area likely to be affected, such as water sources and wildlife areas
- The circumstances leading to the spill
- The action being taken to respond to the spill and by whom
- The agencies or other persons already notified

d. Containment - Preconstructed diking systems are provided wherever feasible. If such dikes are not available, or if the dikes fail, men, equipment and supplies will be transported to the scene of the spill as quickly as possible to implement containment procedures described in the contingency plan. The detailed Spill Contingency and Hazardous Waste Management Plan kept on file contains listings of the manpower, equipment and material available from project sources, from outside contractors, from other companies in the area and from Gulf-Standard as applicable for use in cleanup of spills. The Emergency Coordinator will generally implement the following procedures for spills:

- Source control - This involves the closing of valves and shutting down of equipment and immediate repair of any damaged facility which is causing leaks, even if repairs are only temporary.
- Spread control - Preventing the spill from spreading outside an area of containment by construction of dikes and diversion ditches, spreading of absorbents or use of chemicals to disperse or coalesce spills on water. (This last technique requires special approval by Federal and State agencies.)
- Evacuation - This plan will be implemented in the case of hazardous waste or materials spills that are endangering human life. An Evacuation Plan and the circumstances and authority for implementing the plan are provided in the Spill Contingency and Hazardous Waste Management Plan.

e. Removal and Cleanup - Removal of spilled material, absorbents and associated debris will be initiated immediately following the implementation of the containment procedures outlined above. Immediate removal is important since the cleanup may take several days, and changing weather conditions or equipment malfunctions may expand a controlled spill unless the spill is removed as early as practicable. Specific removal methods will be developed on a case-by-case basis. Available methods include burning in place, absorbing and burning, absorbing and burial in a permitted landfill or recycling through the process incinerator. Hazardous wastes and contaminated soils and containers will either be disposed of in a permitted on-site facility or transported to an off-site hazardous waste disposal site in compliance with transport regulations.

Cleanup of the contaminated area may involve the removal of soaked soil, debris and contaminated vegetation. Additional cleanup can be effected by scrubbing soiled structures with detergent solutions. The extent of cleanup should balance potential ecological damage from the cleanup operations against the potential ecological damage of allowing some of the spill residue to remain for natural biodegradation. Contaminated soils will normally be disposed of in a solid waste landfill or a hazardous waste disposal site, depending upon the nature of the contaminant.

f. Training - Appropriate site personnel will be trained in the proper handling, storage and disposal of oil and hazardous materials and wastes. The degree of training will reflect responsibilities and exposure of the personnel. Training will include the following:

- A review of applicable regulations and requirements
- A discussion of treatment, storage and disposal requirements
- A review of general facility operating procedures
- Review of inspection plan procedures and requirements
- Discussion of waste analysis requirements
- A discussion of closure requirements

The Emergency Coordinator(s) will be trained additionally in the record-keeping and reporting requirements and employee training record requirements.

g. Inspections and Security - Visual inspections of all oil and hazardous waste tanks will be made daily. Collection devices and leak detection systems will be inspected weekly. Facilities will be inspected for signs of leaks, discharges, corrosion or physical damage. Fences and security devices will also be inspected. Problems will be reported to the Emergency Coordinator, who will take appropriate corrective action.

h. Monitoring - The hydrology monitoring program described in Section 9, Chapter 6 provides for the early detection of any spills of oil or hazardous materials or wastes from on-site storage or disposal facilities. Both surface and groundwater are monitored at stations above and below the project area. Any contamination discovered during monitoring will be promptly reported and clean-up measures taken.

i. Closure - Upon abandonment of the site, all oil or hazardous materials or hazardous waste storage facilities will be removed and disposed of in compliance with current regulatory standards.

2. Transportation Off-Site - This section describes the steps to be taken for spills related to the transportation of products and wastes off-site. Notification, containment of the spill, cleanup and repairs are addressed.

The primary objective is to prevent, as far as practical, any damage from spill of oil or hazardous material to persons, property, flora and fauna. As a general rule RBOSC will not transport hazardous wastes off-site. Oil will be so transported. The procedures described herein provide for the prompt reporting, cleanup and proper disposal of any oil or hazardous materials spilled in transit to market or to an off-site disposal facility.

a. Responsibility and Notification - All off-tract spills or other losses shall be investigated immediately by the Emergency Coordinator, regardless of whether such events are reported by employees, aerial patrol, land owners or other individuals.

Based on spill data received, the Emergency Coordinator will decide which agency or agencies should be notified and through proper reporting channels will notify the appropriate agencies.

When appropriate, detailed hazardous materials incident reports will be sent to the Department of Transportation (DOT) in compliance with 49 CFR Part 171.16. These reports will contain the following information:

- Name, address and phone of shipper
- Name and address of carrier
- Destination of shipment
- Date, time and location of incident
- For hazardous waste, a copy of the Hazardous Waste Manifest sent with the shipment (Figure 7-7-2)
- The amount and classification of material spilled
- A description of the material spilled and its hazard class as defined in 49 CFR Part 172.101
- Information on personal injuries and the degree of injury
- The amount of property damage

If it becomes necessary to transport hazardous wastes to off-site disposal areas, RBOSC will further comply with applicable EPA regulations set forth in 40 CFR Part 263 - Standards Applicable to Transporters of Hazardous Waste. These standards require use of a manifest to identify the generator of the

# HAZARDOUS WASTE MANIFEST

HAZARDOUS WASTE

**STRAIGHT BILL OF LADING**
ORIGINAL - NOT NEGOTIABLE

MANIFEST DOCUMENT NUMBER ____________

| TO: T/S/D/F | FROM: Generator |
|---|---|
| E.P.A. ID Code No. | E.P.A. ID Code No. |
| Address | Address |
| Destination | Origin |
| Phone | Phone |

| No Shipping Units | D.O.T. PROPER SHIPPING NAME | HAZARD CLASS | Haz. Mat. ID No. | EPA Haz Waste No. | WEIGHT | LABELS REQUIRED (or Exemption No.) |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

PLACARDS REQUIRED

NOTE - Where the rate is dependent on value, shippers are required to state specifically in writing the agreed or declared value of the property. The agreed or declared value of the property is hereby specifically stated by the shipper to be not exceeding
$ ____________ Per ____________

Subject to Section 7 of the conditions, if this shipment is to be delivered to the consignee without recourse on the consignor, the consignor shall sign the following statement: The carrier shall not make delivery of this shipment without payment of freight and all other lawful charges.
____________
Signature of Consignor

FREIGHT CHARGES
PREPAID ☐ COLLECT ☐

RECEIVED, subject to the classifications and tariffs in effect on the date of the issue of this Bill of Lading, the property described above in apparent good order, except as noted (contents and condition of contents of packages unknown), marked, consigned, and destined as indicated above which said carrier (the word carrier being understood throughout this contract as meaning any person or corporation in possession of the property under the contract) agrees to carry to its usual place of delivery at said destination, if on its route, otherwise to deliver to another carrier on the route to said destination. It is mutually agreed as to each carrier of all or any of said property over all or any portion of said route to destination and as to each party at any time interested in all or any said property, that every service to be performed hereunder shall be subject to all the bill of lading terms and conditions in the governing classification on the date of shipment.
Shipper hereby certifies that he is familiar with all the bill of lading terms and conditions in the governing classification and the said terms and conditions are hereby agreed to by the shipper and accepted for himself and his assigns.

**ALTERNATE DESTINATION (EMERGENCY ONLY)**

T/S/D/F ____________
E.P.A. ID Code No. ____________
Address ____________
Destination

**EMERGENCY RESPONSE INFORMATION**

CONTACT Name ____________
Phone ____________
National Response Center 1-800-424-8802
in D. C. 426-2675

**CERTIFICATION**

This is to certify that the above named materials are properly classified, described, packaged, marked and labeled, and are in proper condition for transportation according to the applicable regulations of the Department of Transportation and the U.S. Environmental Protection Agency.

Generator Signature ____________ Date ____________

TRANSPORTER #1 ____________ E.P.A. ID No. ____________
Address ____________
City ____________ State ______ Zip ______ Phone ______

This is to certify acceptance of the hazardous waste shipment.

Transporter No. 1 Signature ____________ Date ____________

TRANSPORTER #2 ____________ E.P.A. ID No. ____________
Address ____________
City ____________ State ______ Zip ______ Phone ______

This is to certify acceptance of the hazardous waste shipment.

Transporter No. 2 Signature ____________ Date ____________

TREATMENT/STORAGE/DISPOSAL/FACILITY

This is to certify acceptance of the hazardous waste for treatment, storage, or disposal.

T/S/D/F Signature ____________ Date ____________

HAZARDOUS WASTE

**ORIGINAL - RETURN TO GENERATOR**

Figure 7-7-2
Hazardous Waste Manifest Form

waste, the destination of the waste, hazard code, alternate destination if the waste cannot be delivered to the original destination, emergency response information, and certification of receipt. Shipments which do not reach the designated facility within a specified length of time must be reported to the EPA Regional Administrator (303/837-2220).

When a spill of any kind occurs which does or may reach any waters of the State, the spill will be reported at once to the following agencies, in addition to the DOT and the EPA:

- Colorado Water Pollution Control Division, Denver, Colorado (303/388-6111, Ext. 231)
- Oil Shale Office, U. S. Geological Survey, Grand Junction, Colorado
- Bureau of Land Management, Craig, Colorado

Spills which occur in sloughs, ponds or other surface waters where there is any possibility of harm to fish or aquatic life, and spills occurring on land where there is any possibility of harm to game or wildlife habitat will also be reported to the Colorado Division of Wildlife.

If it appears that domestic water users downstream of a spill may be affected, these users will be notified immediately. Notification will be accomplished by contacting the local mayor, water superintendent, city engineer, town marshall and local law enforcement office, etc. In the event that the spill is near or over a road or highway and it is necessary to reroute traffic, the Colorado State Patrol will be alerted at once. The names and the phone numbers of all officials that must be notified are listed in the Spill and Hazardous Waste Management Contingency Plan.

b. Location of Off-Site Spill - The precise physical location of the source of a spill must be determined immediately. Company personnel receiving a report of a spill will obtain all available pertinent information. The manifest which will accompany shipments of hazardous wastes will provide names and phone numbers for reporting spills. It is the driver's responsibility to report such accidents and to ensure appropriate cleanup.

The Emergency Coordinator will be notified immediately and furnished with all available information so that he can stop the spill and arrange for maintenance crews and equipment to be dispatched to the site as quickly as possible.

c. Containment and Cleanup - Containment of the spilled material will be achieved as quickly as possible. Spilled material may be contained in bell holes, or through the construction of catchment basins, earthen dams, separators, weirs or other appropriate means.

Natural avenues of escape such as streams, waterways, ditches and gullies will be followed on foot to determine if the oil or hazardous material or waste has passed through them. If such material is found, containment facilities will be constructed sufficiently ahead of the actual spill movement so that the spill will not reach the containment point before construction of containment facilities is completed.

Contained oil or hazardous material or waste will be removed as quickly as possible to prevent further movement and to reduce hazards. Appropriate means such as suction tank trucks, pumps, skimmers and floating booms will be used for cleanup from water surfaces.

d. Evaluation of Extent of Hazard - In order to minimize possible bodily injury, loss of life, property damage, loss of wildlife or air or water pollution, an accurate analysis of existing hazards and potential hazards will be necessary.

Oil and hazardous materials and waste spills involving congested areas, waterways and watersheds draining into streams or impoundments from which private or public potable water supplies are drawn will require special precautionary measures.

When a spill poses an immediate or potential hazard to the property of third parties, these parties will be notified and consulted in any decisions which might affect their operations or facilities.

e. Reporting - A thorough analysis and detailed hazardous incident report will be made of circumstances and handling of each spill. Hazardous waste spills will be reported in compliance with 40 CFR 272.42 and 49 CFR 171.16. Follow-up actions such as additional training of personnel, spill assessment, repair of equipment and re-evaluation of policies and procedures will follow each incident.

## LITERATURE CITED

U.S. Environmental Protection Agency. 1980. Test Methods for Evaluating Solid Wastes. U.S. Environmental Protection Agency, Office of Water and Waste Management, Washington, D.C.

Section 7

# ENVIRONMENTAL PROTECTION, HEALTH and SAFETY

Chapter 8

# LAND REHABILITATION and EROSION CONTROL

# CHAPTER 8
# LAND REHABILITATION AND EROSION CONTROL

This chapter discusses rehabilitation of disturbed lands to a condition compatible with the stated purposes of the Tract C-a lease. The objectives of the land rehabilitation program described in this chapter are to reclaim disturbed areas by returning them to a state consistent with pre-existing land uses in the area and compatible with existing adjacent undisturbed natural areas.

The principal reclamation techniques considered in this chapter are site preparation, erosion control and revegetation.

## 8.1 AREAS AFFECTED

Table 7-8-1 shows estimates of the disturbed areas on a yearly basis for the Lurgi Demonstration Project on Tract C-a and the adjacent RBOSC off-tract property. The relationship of the RBOSC off-tract property and Tract C-a is shown on Figure 1-1-4.

## 8.2 POST-OPERATIONAL LAND USES

The objective of the RBOSC reclamation plan is to restore affected lands to a self-sustaining rangeland/wildlife habitat similar to that presently existing in the vicinity of Tract C-a. Rangeland on Tract C-a includes primarily the sagebrush vegetation types. Pinyon-juniper, sagebrush, and mixed brush provide important wildlife habitat. The proposed post-mining land uses are compatible with the Piceance Wildlife Habitat Management Plan (1977).

## 8.3 EROSION CONTROL

Although erosion occurs naturally as part of the weathering cycle, it is accelerated by mining and construction activities. Physical disturbance

Table 7-8-1

ESTIMATED ACREAGES OF TERRESTRIAL HABITAT DISTURBANCE
AND RECLAMATION FOR THE LURGI DEMONSTRATION PROJECT

| Source of Disturbance | ACREAGE DISTURBED[1/] 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | Total |
|---|---|---|---|---|---|---|---|
| Construction Related Disturbance | | | | | | | |
| Haul Roads and Associated Disturbance | 44.1 | | | - | | | 44.1 |
| Access Roads and Associated Disturbance | 58.2 | | | - | | | 58.2 |
| Lurgi Plant Site | 45.9 | | | - | | | 45.9 |
| Miscellaneous Valley Bottom Disturbance | 12.2 | | | - | | | 12.2 |
| Shop and Office Facilities Area | 9.8 | | | - | | | 9.8 |
| Possible Expansion Adjacent to MIS Area[2/] | 71.0 | | | | | | 71.0 |
| Subtotals | 241.2 | | | - | | | 241.2 |
| Mining Related Disturbance | | | | | | | |
| Phase One Pit | 26.7 | | | - | | | 26.7 |
| Phase Two Pit | | | | 16.4 | | | 16.4 |
| Subtotals | 26.7 | | | 16.4 | | | 43.1 |
| Storage and Transfer Related Disturbance | | | | | | | |
| Settling Ponds | 31.3 | | | 3.5 | | | 34.8 |
| Topsoil Stockpiles | 50.7 | | | 15.8 | | | 66.5 |
| Overburden Stockpiles | 33.8 | | | 57.8 | | | 91.6 |
| Explosives Storage Area | 0.3 | | | - | | | 0.3 |
| Feed Shale Stockpiles | 37.3 | | | - | | | 37.3 |
| Pit Dewatering Treatment Ponds | 7.2 | | | - | | | 7.2 |
| Lurgi Water Storage Ponds (Bio-treatment and High TDS) | 19.3 | | | - | | | 19.3 |
| Utility Corridors | 39.0 | | | 9.4 | | | 48.4 |
| Subtotals | 218.9 | | | 86.5 | | | 305.4 |
| Disposal Related Disturbance | | | | | | | |
| Phase I Processed Shale Disposal Area | 88.0 | | | - | | | 88.0 |
| Phase II Processed Shale Disposal Area | - | | | 99.8 | | | 99.8 |
| Subtotals | 88.0 | | | 99.8 | | | 187.8 |
| Totals | 574.8 | | | 202.7 | | | 777.5 |

Table 7-8-1 (Cont'd)

ESTIMATED ACREAGES OF TERRESTRIAL HABITAT DISTURBANCE
AND RECLAMATION FOR THE LURGI DEMONSTRATION PROJECT

| | ACREAGE RECLAIMED 1/ | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Source of Disturbance | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | Total |
| Construction Related Disturbance | | | | | | | | |
| Haul Roads and Associated Disturbance | | 8.6 | | | | | 35.5 | 44.1 |
| Access Roads and Associated Disturbance 3/ | | 12.9 | | | | | 42.2 | 55.1 |
| Lurgi Plant Site | | | | | | | 45.9 | 45.9 |
| Miscellaneous Valley Bottom Disturbance | | | | | | | 12.2 | 12.2 |
| Shop and Office Facilities Area | | | | | | | 9.8 | 9.8 |
| Possible Expansion Adjacent to MIS Area 2/ | | | | | | | 71.0 | 71.0 |
| Subtotals | | 21.5 | | | | | 216.6 | 238.1 |
| Mining Related Disturbance | | | | | | | | |
| Phase One Pit | | | | | | | 26.7 | 26.7 |
| Phase Two Pit | | | | | | | 16.4 | 16.4 |
| Subtotals | | | | | | | 43.1 | 43.1 |
| Storage and Transfer Related Disturbance | | | | | | | | |
| Settling Ponds | | | | | | | 34.8 | 34.8 |
| Topsoil Stockpiles | | | 12.3 | | | | 54.2 | 66.5 |
| Overburden Stockpiles | | | | | | | 91.6 | 91.6 |
| Explosives Storage Area | | | | | | | 0.3 | 0.3 |
| Feed Shale Stockpiles | | | | | | | 37.3 | 37.3 |
| Pit Dewatering Treatment Ponds | | | | | | | 7.2 | 7.2 |
| Lurgi Water Storage Ponds | | | | | | | 19.3 | 19.3 |
| Utility Corridors | | 39.0 | | 9.4 | | | | 48.4 |
| Subtotals | | 39.0 | 12.3 | 9.4 | | | 244.7 | 305.4 |
| Disposal Related Disturbance | | | | | | | | |
| Phase I Processed Shale Disposal Area | | 11.0 | | | | | 77.0 | 88.0 |
| Phase II Processed Shale Disposal Area | | | | | | | 99.8 | 99.8 |
| Subtotals | | 11.0 | | | | | 176.8 | 187.8 |
| Totals | | 71.5 | 12.3 | 9.4 | | | 681.2 | 774.4 |

1/ All acreages include a buffer zone, all of which may not be disturbed.
2/ Acreage for on-tract construction camp which is being considered.
3/ Some access roads will be retained for public access, and will not be reclaimed.

exposes materials to erosion mechanisms and increases the rate of erosion. Moving water is responsible for most erosion; however, wind erosion is also a significant factor.

The following paragraphs deal mainly with erosion by water; however, treatments to prevent water erosion and sedimentation are similar to techniques used to prevent wind erosion.

A. Material Size and Classification - Gravelly soils and/or boulders are not likely to erode. Undisturbed clay particles, although very small, are usually erosion resistant because of bonds produced by positive and negative electrical imbalances within the unit cells of the soil particles. Most soils on and adjacent to the tract and the overburden material fall somewhere between these two limits.

Soil erodibility can be rated according to grain size (percent of silt and very fine sand), structure, permeability and organic matter. A given material will be more erosion resistant if it can be made more permeable (more infiltration and less runoff). The least desirable combination of materials from an erosion resistance point of view is a high range (30% to 70%) of silt and very fine sand. One of the most basic and obvious erosion control measures applicable to all slopes is the use of a course material as a cover layer. The longer and steeper the slope, the thicker should be the cover layer.

Erosion rates for recontoured, disturbed areas have been studied using the Universal Soil Loss equation. On 7 percent slopes with vegetative cover, soils and rainfall typical for Tract C-a, erosion rates on undisturbed areas result in a loss of 3.9 tons of soil per acre per year. On mulched and revegetated slopes typical of the processed shale disposal area (3h: 1v), with 120 foot runs between benches and/or other diversion structures, the soil loss would be approximately 3.25 times that calculated for the typical undisturbed areas noted above. At this increased erosion rate a 10-inch layer of topsoil that had been mulched and revegetated would last approximately 105 years. During this period both vegetation cover and soil structure are expected to improve, thus increasing soil stability and reducing erosion.

B. Slope and Surface Treatment - Slope roughening practices will be used to decrease runoff, as well as to slow the water movement. These practices reduce the ability of moving water to detach soil particles and transport sediments. Some of the proposed practices include the following:

- Slope roughening by scarification along the contour of a graded slope. The grooves spread the runoff horizontally, slow its movement downslope and increase the infiltration rate. Roughening is also beneficial in establishing vegetation on a graded area. This practice also increases moisture retention and loosens the soil in the plants' root zone. The horizontal grooves retain soil additives, seeds, and mulch that might otherwise be washed down the slope.
- Operating a bulldozer up and down a graded slope. This practice is referred to as "tracking" and is more adaptable to steep slopes than scarification. The resulting compacted soil may be more beneficial on long or steep slopes exposed to high intensity rainfall because the surface soil particles are packed together thereby resisting erosion. Additionally, the prints left by the grousers on the tracks act to reduce the velocity of the water.

All other factors being equal, a long slope will collect more runoff than a short slope. The greater concentration of water at the base of the longer slope increases the likelihood of erosion. To minimize this problem long slopes will be constructed to function as a series of short slopes (120 feet in length) by utilizing diversion features, such as benches, terraces, ditches and/or dikes. Benching is planned for the processed shale disposal pile and the 3h:1v slopes in the pit. The benches will be carried laterally to a point where drainage can be emptied into a riprapped channel or natural drainage which will carry the water off the slope. Benches will be back-sloped to insure that runoff will remain in the appropriate channel.

Selective placement of individual large rocks and/or brush piles may be included in this treatment to dissipate runoff energy, provide shade for new plants, break up regular structural lines and improve the appearance of the slope.

Reclamation of the pit will consist of backfilling with previously removed overburden to approximately the 6,925 foot elevation. The reclaimed pit bottom will slope to the center and to the east out the haul road to drain into Dry Creek Fork. The south and west highwalls will be reclaimed to a stable slope approximately 1h:1v. Highwalls will not exist on the north and east sides of the pit. The top edges of the south and west highwalls will be rounded to eliminate a sharp edge where erosion could occur. In addition to this a water diversion ditch will be constructed above the south highwall thereby diverting runoff into the adjacent draw to the east.

C. Drainage - Facilities will be provided to drain interception ditches and benches, and to direct the flow of water off the subject area into natural drainage ways. The basic drainage elements will be interception ditches, dikes and channels.

As required, special drainage structures will be used including drain pipes, down drains, chutes and flumes. The drainage structures will be designed to handle the water and sediments that occur as a result of an unusually heavy downpour on bare soil areas.

All haul roads and Lurgi project access roads will be ripped, backfilled, recontoured and topsoiled at the conclusion of the project. The Corral Gulch road from the eastern Tract C-a boundary to the Water Fork turnoff, the road along Water Fork of Corral Gulch, the Airplane Ridge Road, and new roads constructed to allow for public access to the Water Fork and Sagebrush Hill Roads will remain at the conclusion of the project (Figure 7-8-1). Therefore, these new access roads will be constructed to meet BLM specifications and existing roads will be returned to a condition as good as their original state. Water bars and breaks will be constructed to divert water from unsurfaced roadways into natural drainage. Flow velocities will be controlled by energy dissipation devices, such as check dams, plunge pools and rock weirs.

D. Temporary Measures - Temporary erosion control measures will not be provided at sites where grading has been done but revegetation has not been completed, unless specifically required on a site-by-site basis. On sites

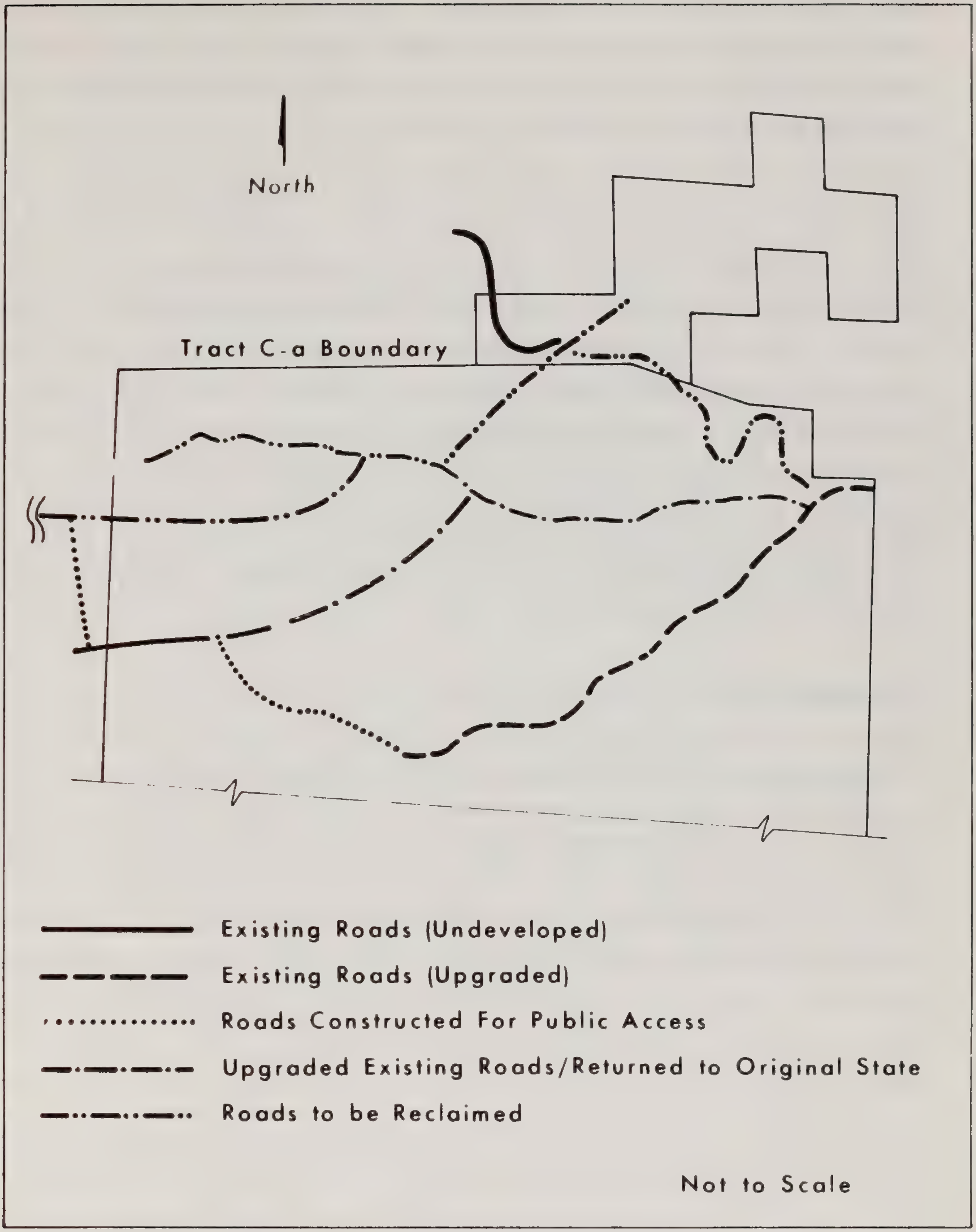



Figure 7-8-1
Permanent Road Locations

where such measures are required, these measures will be designed to facilitate subsequent revegetation. Under normal operating conditions revegetation practices will follow final grading close enough to negate using temporary erosion control measures.

Topsoil stockpiles will be mulched and seeded to prevent loss of soil until these areas are again needed. In cases where additional temporary erosion controls are needed, measures such as furrowing and ripping will be implemented. Road cut and fill areas will be mulched and seeded to prevent erosion. Steep road cut/fill areas which are predominantly rock will not be seeded or mulched. Overburden stockpiles, if used, would be of short duration and would be composed primarily of rock material containing few fines. Consequently, erosion from such piles is not expected to be a problem. Should the percentage of fines in such piles prove to be high enough so that erosion becomes a problem, construction measures such as furrowing and ripping would be implemented. In all cases, runoff from such piles would be contained in settling ponds.

## 8.4 REVEGETATION

A. Introduction - Land disturbed by RBOSC mining development and operation on and in the vicinity of Tract C-a will be reclaimed. Areas will be disturbed by construction of the plant site, roads, open pit, overburden stockpiles, pipelines, water control structures, stockpiling of raw oil shale and disposal of processed shale. The reclamation method of choice is revegetation which provides a self-sustaining vegetative cover that is aesthetically acceptable and provides a post-mining land use that is equal to the pre-mining land use. The pre-mining land use of this area is rangeland and wildlife habitat.

In accordance with Section 11 of the lease stipulations, RBOSC will restore affected lands to a condition at least equal in quality to pre-existing land uses in the area and one that is compatible with adjacent undisturbed areas. The surface rehabilitation plan described herein details the RBOSC revegetation program which has been designed to fulfill all lease requirements and to meet the reclamation performance standards of the Colorado Mined Land Reclamation Board (CMLRB). Implementation of this program will ensure that all land disturbed by RBOSC mining activities is restored to conditions that are at least as good as pre-disturbance conditions. The re-established vegetation will be similar in species composition and functional variety to that pre-existing development.

Baseline studies provided data on existing range trends, browse and soil conditions, and forage production. These studies also determined domestic animal stocking rates and numbers and diversity of wild animal species in the area. These data are presented in the RBOSC Final Environmental Baseline Report (1977). At present, land on and adjacent to Tract C-a is used primarily by cattle, feral horses and wildlife. Needs of these fauna can be provided on reclaimed areas by establishing a plant community which has a species composition and productivity similar to undisturbed areas and by habitat modifications planned as part of the Fish and Wildlife Management Plan (see Section 7, Chapter 11).

B. Revegetation Technology - Revegetation accelerates natural succession because the annual weed stage is largely avoided by seeding perennial grasses and forbs, thereby enhancing the invasion of desirable native perennial forbs (Terwilliger et. al., 1974). Once perennials are established, natural secondary succession may continue for 20 to 50 years (Terwilliger et. al., 1974). The final species composition will depend on soil characteristics, the available natural seed source in the area, climatic conditions during succession, grazing by domestic animals, feral horses and wildlife and the composition of the planted species.

Extensive studies have been done to determine successful means of revegetating processed shale (Berg, 1975; Block and Kilburn, 1973; Culbertson et. al., 1974; Harbert and Berg, 1974; Lipman, 1975). Direct revegetation on processed shale is successful if the shale is leached to a depth suitable for plant growth and if adequate water and nutrients are available. An alternative to revegetating the processed shale directly is to cover the spoils with a non-toxic substrate, such as rock, soil or soil-like material, to provide a medium more suitable for plant growth. This alternative is planned for reclamation of the processed shale disposal area located off Tract C-a. The reconstructed soil profile is designed to isolate the processed shale from the re-established plant community. The effectiveness of such a soil profile is currently being tested as part of the RBOSC experimental revegetation program on Tract C-a.

The results of the RBOSC experimental program initiated in 1975 and 1976, other studies conducted in the Piceance Creek basin (Sims and Redente, 1974; Berg, 1975), and the success obtained in revegetating the drill pads on Tract C-a indicate that available technology is adequate to ensure successful rehabilitation of surface disturbances in the vicinity of Tract C-a.

The sides of the processed shale disposal area will be isolated from the plant community by the thickness of the containment dike. On top of the disposal area only, where there is a potential for the vegetation root systems to contact the processed shale, an artificial soil profile will be reconstructed. This soil profile will consist of up to three feet of relatively course material (six inches and greater) overlain with approximately one foot of subsoil or subsoil-like material. The applicability of various thicknesses of course material will be considered on experimental revegetation plots located on the disposal area (see Section 5, Chapter 4). This will then be covered with approximately 7 to 14 inches of topsoil.

The following discussion outlines the revegetation methods that will be used for reclaiming the lands which will be disturbed by RBOSC. The major types of disturbed lands that will require revegetation include:

- Areas disturbed by the mine and plant site, access roads, support facilities, water control structures, and pipelines
- Processed shale disposal area and associated containment dike. Since the processed shale disposal pile will be reclaimed by constructing a soil profile rather than by direct revegetation of the processed shale, the approach described herein is generally applicable to both types of disturbed areas. Reclamation of both types of disturbed areas will therefore be discussed concurrently.

1. Schedule - The mining and reclamation plans have been coordinated to assure the earliest feasible revegetation of disturbed lands. Table 7-8-1 presents a projection of the annual sequence of land disturbance and revegetation throughout the life of the project. Revegetation of all disturbed areas will begin as soon as is practical after disturbance. Reclamation of the processed shale/overburden site will be completed during the operational period as sections of the pile are completed (Section 5, Chapter 4).

2. Seedbed Preparation - Debris and large rocks which would hamper operation of machinery will be cleared and the areas will be contoured to slopes compatible with the naturally occurring slopes. The out slopes of the processed shale dike will be terraced to reduce erosion and will have an overall slope of 3h:1v or less. The 3h:1v slopes that are to be constructed in the pit will receive similar treatment. Slopes steeper than 3h:1v limit the use of machinery for seeding and increase the potential for soil erosion.

In small areas, (i.e., around buildings, and along haul roads where surface soils have been stripped and stockpiled for later reuse) the surface soils will be scarified and furrowed to reduce erosion until suitable vegetation has been established using the temporary seed mix three presented in Table 7-8-2. Scarifying and furrowing the soil increases water infiltration thereby enhancing vegetative growth.

Topsoil will be stripped from proposed construction and disposal sites to depths indicated on the soil survey map, and stockpiled for use in reclaiming the regraded and processed shale disposal area. In addition, topsoil discovered in depths greater than those listed on the soil survey map will be stripped to the maximum depth of the topsoil as determined by RBOSC personnel. Since stockpiled topsoil may not be used for several years, the stockpiles will be mulched and revegetated with temporary seed mix number two.

Soil studies in the vicinity of Tract C-a indicated that few chemical differences exist between surface and subsurface soils and that rockiness may be the primary factor limiting the use of subsurface soils as a suitable plant growth medium (RBOSP Progress Report 9, 1977),. Sufficient subsoil therefore, will be stripped and stockpiled to cover the top of the processed

TABLE 7-8-2

THREE SEED MIXTURES FOR RBOSC REVEGETATION

| Seed Mixture | Plant Species | | Seeding Rate[1] Approximate (lbs. PLS/acre) |
|---|---|---|---|
| 1 - Permanent | Luna pubescent wheatgrass | | 2.5 |
| | Western wheatgrass | | 3.5 |
| | Sodar streambank wheatgrass | | 2.0 |
| | Indian ricegrass | | 1.5 |
| | Green needlegrass | | 1.5 |
| | Manchar brome | | 1.5 |
| | Cicer milkvetch | | 1.5 |
| | Madrid yellow sweetclover | | 0.75 |
| | Lewis flax | | 1.0 |
| | Winterfat | | 1.0 |
| | Fourwing saltbrush | | 1.0 |
| | Bitterbrush | | 1.0 |
| | | Total | 18.75 |
| 2 - Temporary | Yellow sweetclover | | 1.0 |
| | Barley | | 1.0 |
| | Western wheatgrass | | 6.0 |
| | Luna pubescent wheatgrass | | 8.0 |
| | | Total | 16.0 |
| 3 - Temporary | Yellow sweetclover | | 4.0 |
| | Crested wheatgrass | | 8.0 |
| | Barley | | 8.0 |
| | Luna pubescent wheatgrass | | 5.0 |
| | | Total | 25.0 |

[1] Based on drilling rate; rate for broadcasting and/or hydroseeding will be doubled.

shale disposal area with a minimum of 12 inches of subsoil. This technique of reconstructing the overall soil profile has been investigated on the MIS site revegetation plot R-3.

The soil profile reconstructed on the top of the processed shale/overburden disposal area will provide an adequate quantity and quality of rooting medium to support plant cover and minimize direct root contact with the processed shale. The larger pore size of the overburden material will reduce capillary movement from the processed shale into the rooting zone.

The overburden will in part consist of low grade oil shale which is not of a high enough quality to be processed. The chemical characteristics of oil shale are not expected to inhibit successful plant establishment. Experimental revegetation plots on the disposal site will serve to substantiate this supposition.

3. Seeding - Areas will be seeded as they become available for revegetation. In western Colorado, seeding has been successful in late fall or early spring, although late fall is generally preferable (Cook et. al., 1974).

Seeding on Tract C-a and vicinity will be carried out during the optimal fall period unless disturbed areas will be available for revegetation in spring and would benefit from immediate revegetation.

Since the RBOSC mining operation is expected to disturb land in several different vegetation types, the selected species mixtures will be broad enough that the micro-climates will favor planted species as well as those plants that exist in similar local habitats. The seed mixes listed in Table 7-8-2 have been developed on revegetation test plots in connection with the MIS project. These test plots were initiated in 1975 and 1976 and are still being investigated. As more information is forthcoming it is anticipated that the mixes in Table 7-8-2 will change.

In small surface disturbed areas (ie. topsoil stockpiles, road cut and fill areas), a composite mixture of grasses and forbs such as seed mix number two will be seeded. Shrubs are expected to invade from adjacent areas. In larger areas (ie. processed shale disposal site, Phase II overburden stockpile site), a native composition mixture of grass, forb, and shrub species will be seeded to provide for more rapid introduction of browse and forage species for domestic livestock and wildlife. Seeding of composite mixtures of grasses, forbs, and shrubs as listed in seed mix number one is expected to accelerate succession due to the early introduction and establishment of desirable plant species. Additionally, shrub tublings will be planted in these areas.

Native plant species are preferred because their use reduces the possibility of introducing undesirable exotic species. Exotic species, however, will be included in the seeding mixtures to enhance stabilization.

Seeds will be broadcast or drilled depending on the terrain to be seeded. Drilling will be used on all terrain where machinery can be safely used. Drill seeding will be accomplished using a rangeland type drill. In situations where the rangeland drill does not return sufficient soil to the drill rows to cover the seed, seeded areas may be harrowed after seeding to cover the seed and insure higher germination success. Broadcast seed will be spread by machine or hand-held broadcaster.

Around buildings and other inaccessible areas the hand-held broadcaster will be used.

The seeding rate will depend on the seed mixture and technique selected for the specific area. Temporary revegetation will be accomplished with seed mix two totaling 16 pounds of pure live seed (PLS) per acre (Table 7-8-2). Process facilities and mine site slopes will be temporarily stabilized using seed mix three at a rate of 25 PLS (Table 7-8-2). Areas of permanent reclamation will be drill seeded with 18.75 PLS per acre. Areas that must be broadcast and/or hydroseeded will receive twice the drill seeding amounts as specified in Table 7-8-2.

Certain areas of the processed shale disposal site will be used as experimental seeding plots. These areas are discussed in detail in Part 8.5.

Information gathered from these experimental plots will be incorporated into the seeding plan. Native shrub tublings will also be planted as necessary in the large disturbed areas to reestablish a diverse vegetative cover.

4. Mulch - Hydromulch, straw, native hay and stubble type mulches will be used where applicable. Hydromulch, at a rate of 1,500 pounds per acre, will be used on most steep slopes such as those planned for the outslopes of the processed shale disposal dike and in the reclaimed pit. A tackifying agent will be mixed with the hydromulch in these steep areas. Straw, native hay and stubble type mulches will be used experimentally on the top surface of the processed shale disposal site and other areas. Straw and native hay mulch will be crimped into the surface to stabilize it.

5. Fertilizer - Respread topsoil and/or topsoil-like material will be sampled at a rate of one sample per two acres. These samples will be analyzed to determine the necessary amounts of nitrogen (N), phosphorous (P), and potassium (K), to be added to the topsoil to insure a compatible growth medium for the reclamation vegetation species. Since the life of the project is only approximately five years, it is anticipated that sufficient mycorrhizae will remain in the topsoil to insure proper germination, without having to inoculate the seed prior to planting.

It is expected that no additional organic additives will be required in areas where surface soils will be replaced. In surface disturbed areas where topsoil replacement is not practical during operations (i.e., around buildings), subsurface soils will be revegetated directly.

6. Irrigation - Annual precipitation in the vicinity of Tract C-a varies from approximately 10 to 17 inches (RBOSC Final Environmental Baseline Report, 1977) with higher amounts at the higher elevations on tract. About one-half the precipitation occurs as snow. The preliminary results of the RBOSC revegetation experiments and studies conducted by Sims and Redente (1974) have demonstrated that certain species in the vicinity can be successfully reseeded without supplemental irrigation. However, wide fluctuations in precipitation are common in arid regions, therefore, irrigation will be used but only to supplement the annual precipitation during drought

years. If a drought situation occurs or appears to be occurring, irrigation will be applied at a rate that will keep the reclaimed area at a calculated precipitation level between 10 and 17 inches annually.

7. Biotic Influences and Interactions - Limited fencing of Lurgi Demonstration Project facilities to exclude livestock and feral horses is proposed. Fencing of small areas along roads and around buildings is not practical. The overburden/processed shale disposal pile is proposed for revegetation in segments. Although the size of these areas to be revegetated will be small, concentrations of domestic and/or feral animals may occur. Therefore, the disposal area will be fenced to exclude horses and livestock during phases of disposal, revegetation and testing. Unusually high numbers of animals may be attracted to the pit area when it is reclaimed. If it becomes necessary to protect this area, fencing will be considered.

8. Management - The success of revegetation on seeded areas will be evaluated on a yearly basis. Additional fertilizer and irrigation may be necessary after the first year of establishment. Prompt revegetation in disturbed areas and proper management should eliminate the need to control undesirable plants with herbicides. Any weed control before planting will be done by mechanical methods such as tillage. If it becomes necessary to control weeds after revegetation the Colorado Mined Land Reclamation Board and the Oil Shale Office will be consulted for recommendation.

9. Summary and Conclusion - Much work has been done on revegetation in the arid west, and in recent years investigators have studied the potential application of this work in the Piceance Basin. Extensive studies have been conducted in western Colorado to determine the most effective means of revegetating processed shale. The processed shale and overburden disposal pile represents the most difficult revegetation task for RBOSC because of the limited information available concerning the potential of the reconstructed soil profile to eliminate possible adverse effects of Lurgi processed shale. RBOSC research plot R-3 established in 1976 has demonstrated the effectiveness of revegetation over the reconstructed soil profile outlined earlier.

The work by Sims and Redente (1974) which tested the adaptability of numerous plant species to conditions present in the Piceance Creek Basin is somewhat appropriate to the RBOSC revegetation program. This work investigated the response of plant species shown in pure stands without supplemental irrigation, mulch, or fertilizer. The effects of competition which occur when a composite mixture of grass, forb, and shrub species is sown is known for the results from four years of study on the RBOSC revegetation plots and for Colorado State University intensive study sites. Although available technology seems sufficient to ensure successful revegetation on a limited scale, RBOSC has initiated an experimental revegetation program to investigate problems specific to revegetating the Lurgi processed shale disposal pile (see paragraph 8.5 of this chapter). This program will also gather additional data concerning those aspects of revegetation methodology which have not been studied in detail under conditions existing in the Piceance Creek Basin. RBOSC is confident that they will fulfill all lease and State requirements and successfully reclaim all disturbed lands associated with the development of Tract C-a.

## 8.5 LURGI PROCESSED SHALE RESEARCH PROGRAM

Approximately 62 acres of processed shale will be revegetated during Phase I and II of the demonstration program. Rehabilitation and erosion control consideration relative to this area is presented in Section 5, Chapters 2 and 4.

Section 7

# ENVIRONMENTAL PROTECTION, HEALTH and SAFETY

Chapter 9

## SOLID WASTE CONTROL

The Solid Waste Control Plan describes the expected disposal methods for solid wastes, exluding processed shale and overburden (see Section 5), which are produced during construction and operation phases of the Lurgi Demonstration Project. These solid wastes include process (water and gas treatment) related and non-process (paper, wood, metal, etc.) wastes.

The primary regulations relating to solid waste disposal in Colorado are contained in Chapter 36, Article 23, Colorado Revised Statutes, 1963, as amended. The Colorado Department of Health is charged with administering these regulations. RBOSC will comply with the above law and in addition to all applicable Federal and local laws, rules and regulations.

## 9.1 NON-PROCESS WASTES

A. Construction Phase - The estimated amount and proposed method of disposal for solid wastes during construction phase are listed on Table 7-9-1 below. There will be no process wastes during construction, except during start-up. The estimated quantities are based on manpower projections and construction activities.

B. Plant Operation

1. Composition and Quantity - The estimated composition of non-process solid wastes during plant operation is shown on Table 7-9-2.

A rough estimate of the quantity of waste generated by the project during plant operation has been made based on manpower projections and fifty percent plant operating factor. The solid waste is estimated to be one ton per day.

2. Collection and Transport - Nonrecyclable waste will be collected in covered steel containers placed conveniently around the Lurgi Demonstration Project area. The capacity of the containers will vary from one to five

Table 7-9-1

SOLID WASTE DURING CONSTRUCTION PHASE

| Material | Estimated Quantity (Tons/Month)[1] | Proposed Disposal |
|---|---|---|
| Packaging and Shipping Materials | 60 | Rio Blanco County Solid Waste Disposal Site |
| Paper | 2 | Rio Blanco County Solid Waste Disposal Site |
| Wood | - | Reuse[2] |
| Metal | - | Reuse[2] |
| Empty Containers (non-returnable drums, barrels, etc.) | 3 | Rio Blanco County Solid Waste Disposal Site |
| Damaged Equipment or Parts | - | Repair or return to Vendor |
| Miscellaneous Inorganics | 15 | Rio Blanco County Solid Waste Disposal |

1. This includes mechanical start-up (pre-operational check-out of equipment).
2. Non-reusable scrap wood and metal at the completion of construction phase will be disposed at the Rio Blanco County Disposal Site.

TABLE 7-9-2

COMPOSITION OF NON-PROCESS SOLID WASTES

| Material | Weight Percent |
|---|---|
| Paper | 29 |
| Organic Waste | 8 |
| Glass | 9 |
| Nonrecyclable Metals | 15 |
| Wood | 8 |
| Plastics | 9 |
| Rubber and Leather | 15 |
| Textiles | 5 |
| Miscellaneous Inorganics | 2 |
| Total | 100 |

cubic yards depending on the nature and volume of waste. A collection-compactor truck will collect the waste on a regular schedule and transport it to Rio Blanco County disposal site.

Separate containers, suitably marked, will be provided for recyclable materials. Vendors will probably call at the project to collect some recyclable material. That material not collected by vendors will be transported to recycle centers by available project transportation.

3. Disposal - All solid wastes that is not recycled will be disposed in Rio Blanco County disposal site. Recyclable materials will probably be repaired or returned to vendors.

## 9.2 PROCESS WASTES

The principal solid wastes produced during plant operation are spent zeolite water softening resins from the water treatment system which will be approximately three TPY.

The spent zeolites will be disposed of in the Rio Blanco County disposal site.

No solid waste is anticipated from the product gas incinerator and $SO_2$ scrubber.

Section 7

# ENVIRONMENTAL PROTECTION, HEALTH and SAFETY

Chapter 10

# AESTHETICS

The principal aesthetic value of Tract C-a and its environs is the landscape, which is characterized by rolling hills with flat-topped ridges and rounded canyon walls dropping steeply 100 to 300 feet into narrow, flat-bottomed valleys. Aesthetic values were considered in planning all facilities and operations of the Lurgi Demonstration Project. Criteria used to minimize the visual impact of the Lurgi Demonstration Project and preserve scenic values are discussed in the following paragraphs.

## 10.1 LOCATION

The visual impact of engineering features is greatly affected by their location and surroundings. The following concepts will be applied in minimizing this impact:

- Make outlines as nearly parallel to natural ground lines as possible
- Locate transmission lines and pipelines so that extensive clearing will not be required
- Locate transmission lines so that they will cross ridges in natural depressions, when possible (see Figure 7-10-1)
- Minimize land disturbance through the multiple-use corridor concept

## 10.2 MATERIALS AND COLOR

Exposed construction materials will be selected or painted to reduce their visual impact. Bright colors and bare galvanized steel will be avoided where possible. The processed shale pile will be covered with overburden material and topsoil (and, ultimately, vegetation) to blend with the natural background. The open pit mine, upon abandonment, will also be partially backfilled with overburden material and, covered with topsoil and revegetated.

Poor Location & Excess Clearing

Good Location & Minimum Stripping

Figure 7-10-1

Power Line Routing and Construction

## 10.3 SHAPE

Major processing structures and buildings have distinctive shapes, and little can be done to alter these shapes without interfering with their operational and economical functioning. However, in earthmoving activities, overburden, topsoil and processed shale disposal construction, shape will also be used as means of reducing visual impact as follows:

- Changes from formal to natural lines will be made gradually.
- Slope rounding will be used to blend man-made slopes into the natural ground shape (see Figure 7-10-2).
- Benches and terraces will be used to break up long slopes (see Figure 7-10-3).
- Natural looking ridges and valleys will be constructed in large disposal piles.

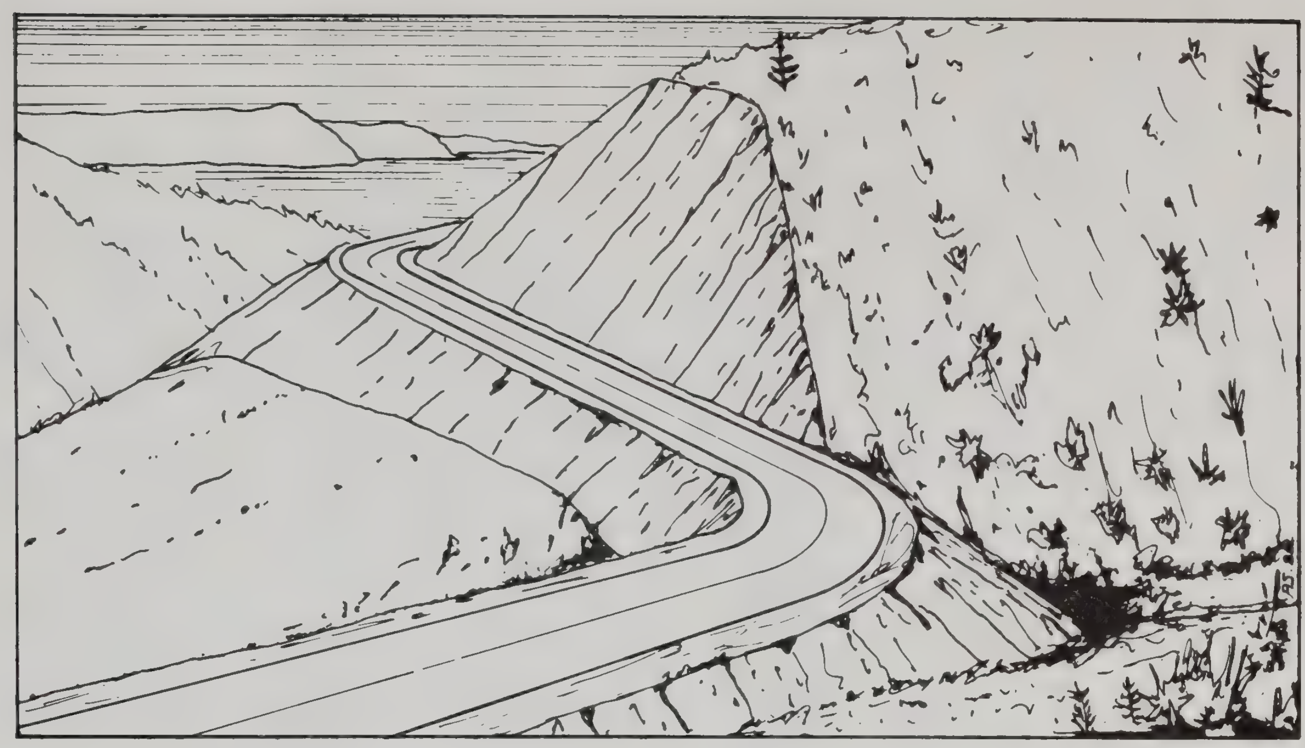
## 10.4 VEGETATION

The ultimate success in minimizing visual impact will depend largely on the success of the revegetation program. Contrasting vegetation types will be used to enhance the appearance of the overall project. However, any new vegetation will be chosen to blend with existing vegetation.

Movements of overburden and topsoil, and disposal of processed shale will be coordinated with revegetation efforts to aid in the control of sedimentation and erosion and in the restoration of vegetation. Such coordination of efforts will contribute to the development of aesthetically pleasing designs and facilitate operation and maintenance.

Cuts and embankments, properly constructed and revegetated, will soon become part of the landscape, requiring minimal attention and maintenance.

Revegetation is discussed in Section 7, Chapter 8.

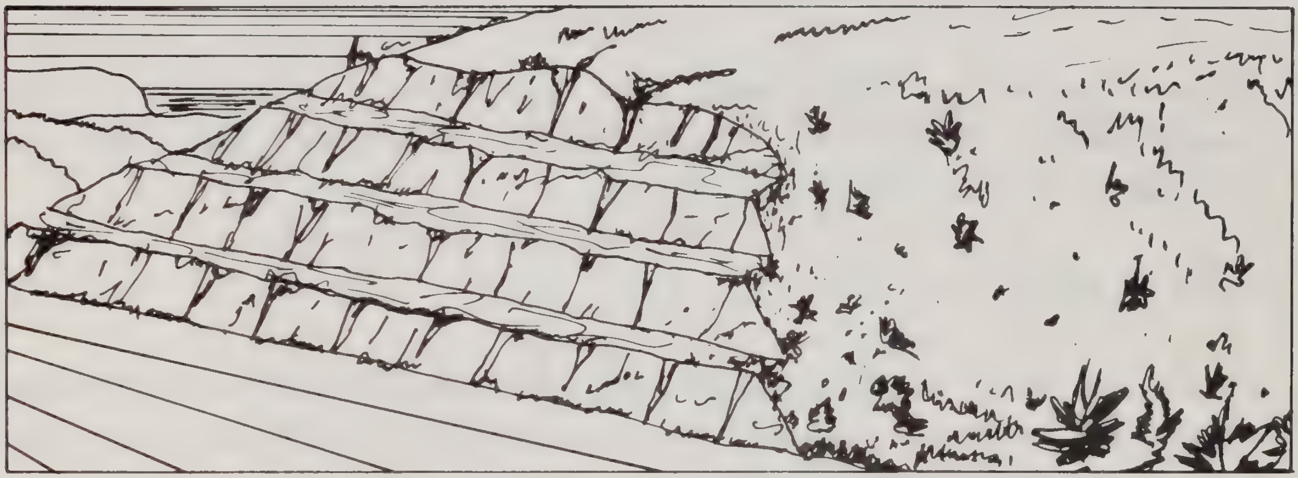


Untreated

Slopes Rounded & Revegetated

Figure 7-10-2
Slope Rounding

Untreated Slope



Formal Benching

Informal Benching

Figure 7-10-3

Benching & Terracing

## 10.5 CLEARING

In the Lurgi Demonstration Project area, several techniques will be employed to minimize the visual impact. Most of the vegetation consists of types that have limited height. In areas where sagebrush predominates, there is little need to clear a wide straight path for a transmission line.

In areas where pinyon-juniper vegetation exists, the same technique can be used. Transmission lines will be constructed with sufficient clearance between conductor cables and vegetation. Topping or removal of tall trees may be required in local areas.

When clearing a right-of-way, all vegetation possible will be left undisturbed. "Dozed" paths will not be permitted. Only the larger vegetation will be removed.

## 10.6 SIGNS

Signs will be of rustic appearance and constructed to blend with the natural landscape. However, they will not be camouflaged so that the public cannot see them and heed their warnings.

Signs on State and County highways will comply with the standards of the respective State or County highway agency. All other road signs will be designed in accordance with BLM Standard No. 9132.

## Section 7

# ENVIRONMENTAL PROTECTION, HEALTH and SAFETY

## Chapter 11

# FISH and WILDLIFE MANAGEMENT PLAN

CHAPTER 11

# FISH AND WILDLIFE MANAGEMENT PLAN

The Tract C-a lease environmental stipulations require RBOSC to avoid, minimize, and/or mitigate damage to fish and wildlife habitat. Section 4 of the Environmental Stipulations requires that RBOSC submit:

> "a detailed fish and wildlife management plan which shall include the steps which the Lessee shall take to: 1) avoid or, where avoidance is impracticable, minimize damage to fish and wildlife habitat, including water supplies; 2) restore such habitat in the event it is unavoidably destroyed or damaged; 3) provide alternate habitats; and 4) provide controlled access to the public for the enjoyment of the wildlife resources on such lands as may be mutually agreed upon. The plan shall include, but not be limited to, detailed information on activities, time schedule, performance standards, proposed accomplishments, and ways and means of avoiding or minimizing environmental impacts on fish and wildlife" (p. A-17).

The Fish and Wildlife Management Plan presented in this chapter is designed to meet this requirement. Although the Lurgi Demonstration Project will involve lands both within and outside Tract C-a, RBOSC is committed to mitigating, to as great an extent as possible, the potential adverse impacts to fish and wildlife resulting from project activities, regardless of the location of these activities. The development of an adequate Fish and Wildlife Management Plan involves three tasks, as follows.

- Assessment of baseline wildlife habitat conditions in the area subject to loss or removal from wildlife use
- Quantification of potential adverse impacts of proposed actions
- Formulation of a program to avoid and/or mitigate such impacts

An extensive study of the terrestrial and aquatic ecosystems of Tract C-a and vicinity including the proposed Lurgi Demonstration Project area was conducted by RBOSC during the two years of baseline environmental studies.

Aquatic habitat is limited in the vicinity of Tract C-a. The nearest fish populations occur more than 20 miles away in the White River. Pinyon-juniper and Sagebrush vegetation types dominate the terrestrial habitats and support a diversity of wildlife. A complete description of the environment of Tract C-a and vicinity is presented in the RBOSP Final Environmental Baseline Report (1977). The environmental setting and wildlife inventory of Tract C-a and vicinity are also summarized in Section 8, Chapter 2.

The potential adverse impacts to wildlife habitats of the proposed Lurgi Demonstration Project activities were assessed using a technique similar to the matrix analyses used for assessment of MIS activities (Leopold et al. 1971). Information relating to proposed project activities and existing ecological relationships was used to assess the importance and severity of potential impacts. A detailed description of the original MIS assessment process is contained in Section 8, Chapter 1 of this document. Potential primary and secondary adverse impacts to wildlife and their habitat are described in detail in the terrestrial ecology impact assessment section of this document (Section 8, Chapter 4), and in other chapters in Section 7 which outline environmental control programs designed to minimize project-related changes in ambient noise levels (Chapter 4), ambient air quality (Chapter 5), and existing water supplies and quality (Chapter 6).

The environmental control programs mentioned above will mitigate or avoid many potential adverse impacts to wildlife and their habitat which might otherwise result from changes in existing air quality, noise levels, water supplies, or water quality. The remaining impacts, which involve temporary or long-term habitat loss and general hazards to wildlife caused by physical destruction or damage to habitat, exclusion by fencing or other obstruction, and increased human activity are addressed directly by the mitigation/avoidance program presented in this management plan. The program is divided into four parts: wildlife habitat enhancement, wildlife habitat restoration, human disturbance control, and vegetation modification monitoring program.

RBOSC will cooperate fully with the OSO and appropriate government agencies, in accordance with the lease agreements, in implementing the Fish and Wildlife Management Plan. RBOSC will address multiple interests (e.g., range management, wildlife resources, and protection of feral horses) in development of wildlife habitat alteration programs, and will coordinate the development and implementation of such programs with the OSO for areas within Tract C-a. Any activities on off-tract lands will be conducted in cooperation with the BLM and CDOW as well as the OSO. Before implementing any off-tract programs, RBOSC will meet with BLM and CDOW personnel to insure that the programs are compatible with future agency plans that they may have for fish and wildlife management in the Piceance Creek Basin.

## 11.1 WILDLIFE HABITAT ENHANCEMENT

The activities associated with the Lurgi Demonstration Project will result in both temporary and permanent loss of wildlife habitat. The extent (acres, location, etc.) of these impacts is described in detail in the assessment of potential terrestrial ecology impacts in Section 8, Chapter 4. The habitat enhancement portion of the Fish and Wildlife Management Plan is designed to offset these impacts by increasing the carrying capacity of non-impacted wildlife habitats. This will be accomplished by modifying habitat and increasing water availability.

A. Habitat Modification - The proposed RBOSC habitat modification program will increase the carrying capacity of non-disturbed habitats for mule deer, the principal wildlife species in the area. Numerous modification techniques have been used to increase the carrying capacity for wildlife and/or livestock of pinyon-juniper and sagebrush habitat types. These techniques typically utilize physical alteration, burning or chemical application to remove or kill pinyon, juniper or sagebrush species. This results in decreased competition between these unwanted species and more desired species for available light, water and soil nutrients. The desired result is an increase in wildlife and/or livestock forage, thereby increasing the carrying capacity of the habitat.

The critical factor which currently limits mule deer populations in the Piceance Creek Basin is the availability of suitable food during periods of heavy snow cover. Thus, a program designed to increase the carrying capacity of local habitats for mule deer in the area should be aimed at increasing suitable forage as well as providing access for mule deer to the modified area during periods of heavy snow cover. Habitat modification in large, continuous blocks increases wildlife forage in these areas, but such large areas commonly fill with snow during severe snow periods making the area inaccessible to deer. The RBOSC habitat modification program is designed to avoid this problem by modifying vegetation in strips, leaving the vegetation between strips undisturbed. The undisturbed strips provide cover and access routes to the modified areas.

The first phase of the habitat modification program was initiated in the fall of 1980 on an experimental basis in a limited area (Figure 7-11-1). The program is designed to evaluate the effects of several factors critical to increasing deer carrying capacity: 1) snow depth, 2) moisture availability during the growing season, 3) selective brush removal, 4) quality forage, and 5) fertilization.

Decadent sagebrush in Stake Springs Draw about 2 miles east of Tract C-a was removed in narrow, parallel strips separated by non-altered sagebrush. Two sets of strips were converted, using a tractor-towed roto-chopper. One set is oriented along the axis of most winter winds; the other set is perpendicular to winter wind direction. A differential accumulation of snow should occur from one set to the other. Various combinations of planting favoring deer forage, and fertilizing are being used to provide a range of treatments. Control (untreated) areas are located near each of the treatment areas.

Many of the nongame wildlife species identified during baseline studies as occurring in bottomland sagebrush habitat will benefit from this modification, due to increased seed and forage production. No adverse impacts to wildlife are anticipated.

B. <u>Modifying and/or Increasing Water Availability</u> - RBOSC will attempt to increase wildlife carrying capacity in dry areas which are otherwise suitable for wildlife habitat by installing surface runoff collectors to provide open water. The number and location of runoff collectors to be built will be determined by RBOSC in consultation with the OSO, BLM and CDOW. Sites should be on gentle north-facing slopes to minimize evaporation and elevation of water temperatures caused by solar radiation.

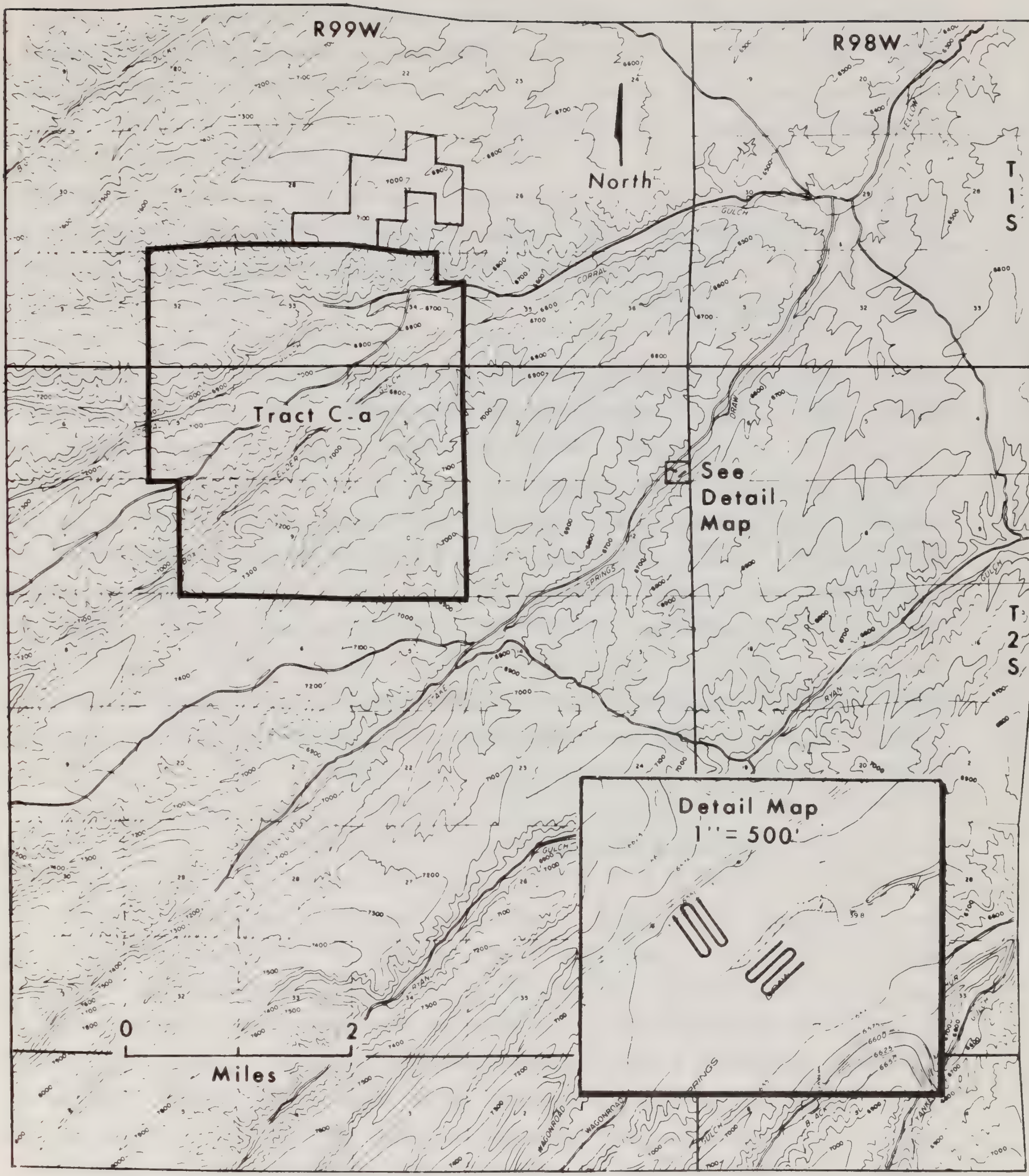



Figure 7-11-1
Wildlife Habitat Modification

Runoff collectors will be placed near suitable escape cover so that small animals using the collectors are not subjected to increased predation. Dense vegetation that might prevent the detection of predators by wildlife using the runoff collectors will be avoided.

Typical collectors consist of three basic components: the apron, the cistern or tank, and an enclosed ramp. Details of runoff collector construction and placement will be determined by RBOSC in consultation with the OSO, BLM, and CDOW on a case-by-case basis.

Another method of increasing wildlife carrying capacity in an arid environment is the creation of wet meadows. A wet meadow is an area, usually only a few acres in size, that is irrigated to produce succulent vegetation during normally dry seasons. Wet meadows will be created by trucking and/or pumping water to sites or using a combination of snow collection and runoff diversion structures to increase the amount and duration of surface runoff and to concentrate this runoff at selected sites. Sites to be developed as wet meadows will be seeded with a wildlife-oriented seed mix prior to initiation of watering measures. New sites will be protected from large herbivores until the plant community is sufficiently established to support such utilization. Suitable areas for development of wet meadows will be selected by RBOSC in consultation with the OSO, BLM, and CDOW.

## 11.2 WILDLIFE HABITAT RESTORATION

Project-related activities will result in temporary loss of wildlife habitat due to disturbance. These disturbed areas will be reclaimed as described in Section 7, Chapter 8. Reclamation will involve recontouring, replacing topsoil, and revegetating disturbed areas. Wildlife as well as erosion control considerations were considered in developing the proposed reclamation plan. Seeding will provide for vegetation communities similar to the pre-disturbance communities, so that the reclaimed area can support numbers and species of wildlife similar to the pre-disturbance wildlife community.

The RBOSC reclamation plan will provide for restoration of disturbed wildlife habitat in a timely manner, in accordance with the stipulations of the lease agreement.

## 11.3 HUMAN DISTURBANCE CONTROL

The increased human activity associated with the Lurgi Demonstration Project has the potential to adversely impact the wildlife of the project area. These potential adverse impacts include increased wildlife mortality due to roadkill and/or increased hunting pressure (legal and illegal) as well as increased wildlife harassment due to off-road vehicle use and/or disturbance by humans or their pets. RBOSC will mitigate these potential impacts through a combination of education efforts and employee regulations.

A slide show which discusses driving habits which reduce the likelihood of roadkill of the important wildlife species of the Tract C-a area has been developed for employees and visitors. Speed limits will be posted in the project area, and deer crossing signs will be placed in appropriate areas.

Potential adverse impacts due to excessive hunting pressure will be mitigated by distribution and posting of information concerning hunting and trapping regulations. This information will be posted in conspicuous places as required by lease stipulations. Hunting and trapping on restricted portions of the project area will be prohibited. RBOSC will consider the conviction of any employee for job-related game violations as grounds for disciplinary action.

A brochure which describes the undesirable safety and ecological aspects of off-road vehicle use has been developed for employees and visitors. All vehicles will be restricted to designated roads, construction areas, and disposal areas; and barriers will be erected to prevent traffic through sensitive wildlife areas.

The potential adverse wildlife impacts caused by the presence of people and their pets are also discussed in the abovementioned brochure. Harrassment of wildlife by RBOSC employees or their pets will be prohibited.

Such secondary impacts will be further reduced by using buses to transport the majority of the work force to and from the project area.

In addition to implementing the mitigation/avoidance program which has been described, RBOSC will comply with all of the stipulations of Tract C-a oil shale lease which address fish and wildlife concerns. In response to one of these stipulations, RBOSC will install devices on all powerlines to prevent raptor electrocution.

## 11.4 HABITAT MODIFICATION MONITORING PROGRAM

The success of the habitat modification portion of the Fish and Wildlife Management Plan will be monitored to determine the level of success. This will include analyses of the changes in vegetative productivity, and utilization of vegetation by mule deer. Specific monitoring activities will include:

- Range and browse species productivity analyses
- Pellet groups analyses
- Photographic monitoring of deer distribution between treatment and control areas
- Observations of wildlife species utilizing the areas
- Observations of livestock utilizing the areas

These monitoring activities will be designed to determine if the habitat modification program results in a statistically significant difference in mule deer forage and/or mule deer utilization between the treated and control areas. This determination will be achieved by comparison of modified areas with adjacent control areas. The effects of various combinations of aspect, strip orientation, and seed/fertilizer application will also be determined through comparisons within the modified areas. An optimum treatment will be identified, provided that the results of the modification are positive.

If the experimental habitat modification program produces positive results, the program will be expanded to larger areas. A tentative proposal involves application of the modification program to one of the large (approximately 9 square miles) blocks used to monitor mule deer density which have been established as part of RBOSC's ongoing terrestrial ecology monitoring program (see Section 9, Chapter 4 of this document). Baseline data on mule deer density are available for these blocks. Mule deer distribution among these blocks has also been established. These data could provide a reference for analyzing the effects of the vegetation modification program on the densities and distribution of mule deer on a large scale. RBOSC will work closely with the CDOW, the OSO, and the BLM in the development and application of any such habitat modification program.

## LITERATURE CITED

Rio Blanco Oil Shale Project. 1977. The Final Environmental Baseline Report. Gulf-Standard, Denver, Colorado.

## Section 7

# ENVIRONMENTAL PROTECTION, HEALTH and SAFETY

## Chapter 12

# PROTECTION of OBJECTS of HISTORIC and SCIENTIFIC INTEREST

# PROTECTION OF OBJECTS OF SCIENTIFIC AND HISTORIC INTEREST

An intensive cultural resource survey of Tract C-a and vicinity was conducted as part of the two-year environmental baseline studies program. The cultural resource survey was conducted to establish the presence or absence of significant cultural resources, and to assess the potential impacts of proposed development on such cultural resources. Archaeologic, historic, and paleontologic studies were conducted. The Cultural Resources Baseline Study included:

- Searching State site files for archaeologic, historic, and paleontologic resources and contacting the State Historic Preservation Officer for additional information on these resources.
- Searching the literature for background information on the cultural resources of the area.
- Searching the National Register of Historic Places for Rio Blanco County, Colorado.
- Conducting an intensive (100%) survey of the cultural resources of Tract C-a and adjoining areas including the land acquired by RBOSC from the CDOW. This survey was conducted in compliance with stipulations set forth in Tract C-a Oil Shale Lease Environmental Stipulations and References (U.S. Dept. Interior, BLM), the Antiquities Act of 1906, the National Historic Preservation Act of 1966 (as defined in 36 CFR 800), the National Environmental Policy Act of 1969, the Archaeological and Historic Preservation Act of 1974, Executive Order 11593 of 1971, 40 CFR Part 1500 - Guidelines for the Preparation of Environmental Impact Statements, the Colorado State Antiquities Act of 1973, and the Colorado Land Use Act of 1974.

Following completion of field surveys and laboratory analysis, a Cultural Resources Survey Report was published (RBOSP, 1976). The report included an evaluation of the importance of cultural sites relative to the National Register of Historic Places based on criteria set forth in Federal Register, Vol. 41(82), 27 April 1976. The Cultural Resources Survey Report was submitted for review and comment to the DCM/OS; BLM; the State Historic Preservation Officer; and the Advisory Council on Historic Preservation, pursuant to the Historic Preservation Act of 1966. These reviews culminated in the issuance of a "Determination of Effect" by the Colorado State Office of the BLM. The Determination of Effect was received by the DCM/OS on January 6, 1977. The Determination of Effect was prepared in compliance with Executive Order 11593, Section 106/2b procedures. On February 3, 1977, Mr. Dale Andrus, Director of the Colorado State Office of the BLM, received a letter of concurrence from Mr. Bruce E. Rippeteau, State Archaeologist, for the State Historic Preservation Officer. This letter was followed on February 15, 1977 by a second letter of concurrence from Mr. James E. Hartman, Curator, Colorado Historical Society, for the State Historic Preservation Officer. The Determination of Effect included a determination of the significance of cultural resources in the study area in terms of eligibility for the National Register of Historic Places, guidelines designed to provide protection for significant cultural resources, and a determination of the expected impact of proposed RBOSC activities.

After review of the Cultural Resources Survey Report (RBOSP, 1976), the BLM determined that two sites in the survey area may be eligible for the National Register of Historic Places. The first of these is identified in the report as Site Cluster II, and is located to the east and north of Tract C-a, encompassing portions of the 84 Mesa, Corral Gulch, Yellow Creek, and Stakes Springs Draw drainages. The second site, 5RB13, is located in the southeast corner of Tract C-a. Both of these are archaeologic sites. No historic or paleontologic sites in the area were deemed significant.

The recommendations for protection of Cultural Resources included in the Determination of Effect are as follows:

- "Site Cluster II shall be avoided wherever possible during the construction and operation phases of the proposed plan. Site Cluster II, located near 84 Mesa, will not be affected by most construction. The sites that may be affected shall be flagged and primary sites will be tested and salvaged by a qualified archaeologist upon disturbance or threat of disturbance. All artifacts removed shall be mapped, recorded, and then curated by an approved institution and/or laboratory."

- "Site Number 5RB13, located on Tract C-a, shall be tested and if necessary excavated by a qualified archaeologist (prior to disturbances). All materials shall be mapped, recorded, photographed, and curated by an approved institution or laboratory."
- "The lessee shall immediately bring to the attention of the lessor, through the Mining Supervisor, any and all antiquities or other objects of historic or scientific interest including but not limited to historic or prehistoric ruins, fossils, or artifacts discovered as a result of operations under this lease and shall leave such discoveries intact until told to proceed by the Mining Supervisor. In cases where salvage excavation is necessary, the cost of such excavations shall be borne by the lessee."

The Determination of Effect issued by the BLM concluded that RBOSC's proposed project activities would have no adverse effect on significant cultural resources within the study area, provided that the recommendations included in the Determination of Effect are complied with. This document presents a plan to construct and operate a surface retort using open pit mining to provide oil shale feed. This will affect different areas than those described in the Revised DDP. On October 30, 1980, RBOSC requested that the State Historic Preservation Office review the adequacy of the existing cultural resources data collected for the study area and determine if the existing archeological clearance also applies to the lands to be affected by construction and operation of the Lurgi demonstration facilities. Confirmation from the State Historic Preservation Office that the existing data are adequate and that the existing archeological clearance was applicable for the Lurgi Demonstration Project was received by RBOSC on November 17, 1980, and was provided to the OSO.

## 12.1 PROTECTION MEASURES

RBOSC proposes to adhere to the guidelines provided in the January 6, 1977 Determination of Effect. In response to these directives, RBOSC proposes a program to protect significant cultural resources which includes:

- Development, Planning, and Scheduling - Inadvertent damage to significant cultural resource sites will be prevented by pre-planning of activities to avoid sites recommended for protection. RBOSC coordinators have been supplied copies of maps and legal descriptions of significant cultural resource sites and are required to continuously scrutinize development activities in the aforementioned areas. Once disturbance is at hand, threatened sites will be flagged and a qualified archaeologist will be engaged to test primary sites within Site Cluster II and/or Site 5RB13. The archaeologist will be engaged in ample time to complete testing and salvage of the site before disturbance occurs. The DCM/OS will be kept apprised at all times of RBOSC actions involving such sites, and development will proceed only after the DCM/OS has issued permission to do so.
- Equipment Operator Training - Equipment operators will be provided with enough information to recognize the presence of historic and scientific resource material, particularly that which is in the subsurface. In the event potentially significant historic or scientific resource material is unearthed, work will stop in the immediate area until the find is cleared and permission to resume operations has been granted by the DCM/OS. All finds will be reported to the BLM and the State Historic Preservation Office as well as the Mining Supervisor.

Should it become necessary to disturb any areas not previously investigated by a qualified archaeologist and/or historian, RBOSC will engage such an individual to survey the area and evaluate its potential, prior to the disturbance. This is an unlikely contingency, as the entire area proposed for development in this plan is within the 100 percent survey area originally inspected and cleared.

In addition, employees will be prohibited from collecting or hunting artifacts as per law and will be asked to report all finds to RBOSC management.

These measures are expected to provide ample protection for significant cultural resources in the study area.

## LITERATURE CITED

Rio Blanco Oil Shale Project. 1976. A Cultural Resource Survey Report. Gulf-Standard, Denver, Colorado.

## Section 7

# ENVIRONMENTAL PROTECTION, HEALTH and SAFETY

## Chapter 13

# ABANDONMENT

# CHAPTER 13
# ABANDONMENT

## 13.1 INTRODUCTION

Abandonment of a mining site within the State of Colorado and/or on Federal property requires that certain procedures be followed. RBOSC will adhere to these agency guidelines. The Lurgi demonstration is planned as a two phase operation. If the project is terminated at the end of Phase I or Phase II, abandonment will be carried out in accordance with MLRB regulations and the oil shale lease. In the interim between the beginning of the project and its termination, certain areas of the processed shale disposal site will be reclaimed. If RBOSC chooses to abandon the lease, a notice of relinquishment will be filed with the OSO. A detailed abandonment plan would be provided to the OSO for approval prior to abandonment.

If the facilities should be sold by RBOSC as an operating facility, the abandonment responsibility will be transferred to the new owner. Also, for a period of six months after termination of the lease, the leasor has the right to purchase, at appraised value, any and all items on the lease required as useful for the protection of the leased land.

## 13.2 GENERAL PROCEDURES

The abandonment procedures will be determined by the guidelines provided by the regulatory agencies and the environmental programs described in this document. The primary objective will be to return the site to a stable physical state which is compatible with the surrounding ecosystem. The removal of the obvious signs of man's activities and the establishment of a self-sustaining vegetative cover will be a major part of the process.

The details of the erosion control and revegetation programs are provided in Section 7, Chapter 8. These programs will be preceded by the salvage and/or demolition of the facilities.

Established environmental monitoring programs will be continued until it is determined that the conditions required by Federal and State regulations have been satisfied. The OSO may terminate these programs at an earlier date at its discretion.

## 13.3 MINE

The mine has been designed as a two phase operation. Phase I will include the construction of the basic pit and extraction of 1.2 million tons of Mahogany zone oil shale. Phase II will provide for the expansion of the pit to provide an additional 1.8 million tons of this material.

The mine could be abandoned and reclaimed after either phase, depending upon the results of the Lurgi Demonstration Project. The primary goals of the abandonment and reclamation procedure are (reference is given to the section/chapter where detailed information can be found):

- Provide a stable physical condition to eliminate slope failures (Section 2, Chapter 5) and minimize erosion (Section 7, Chapter 8).
- Allow for the re-establishment of premining hydrologic conditions (Section 8, Chapter 6).
- Provide a vegetative cover which will be self-sustaining (Section 7 Chapter 8).
- Allow wildlife to return to the area (Section 7, Chapter 11).
- Minimize visual disruption to the area (Section 7, Chapter 10).

Figure 7-13-1 depicts the reclaimed topography of the Phase II open pit in plan view. Sections A-A and B-B shown on Figure 7-13-1 are illustrated on Figure 7-13-2 and 7-13-3 respectively. To achieve the reclaimed topography of the pit, material will be hauled to the open pit from the east gulch fill, haul road and mine facilities fill, and the fill adjacent to the haul road. This material constitutes 3.7 million bcy and is sufficient to backfill the pit on the west end to an elevation of 6925 feet msl. From this point the pit bottom will be graded to provide drainage at approximately 1% to the east into Dry Fork Gulch as shown on Figure 7-13-3.

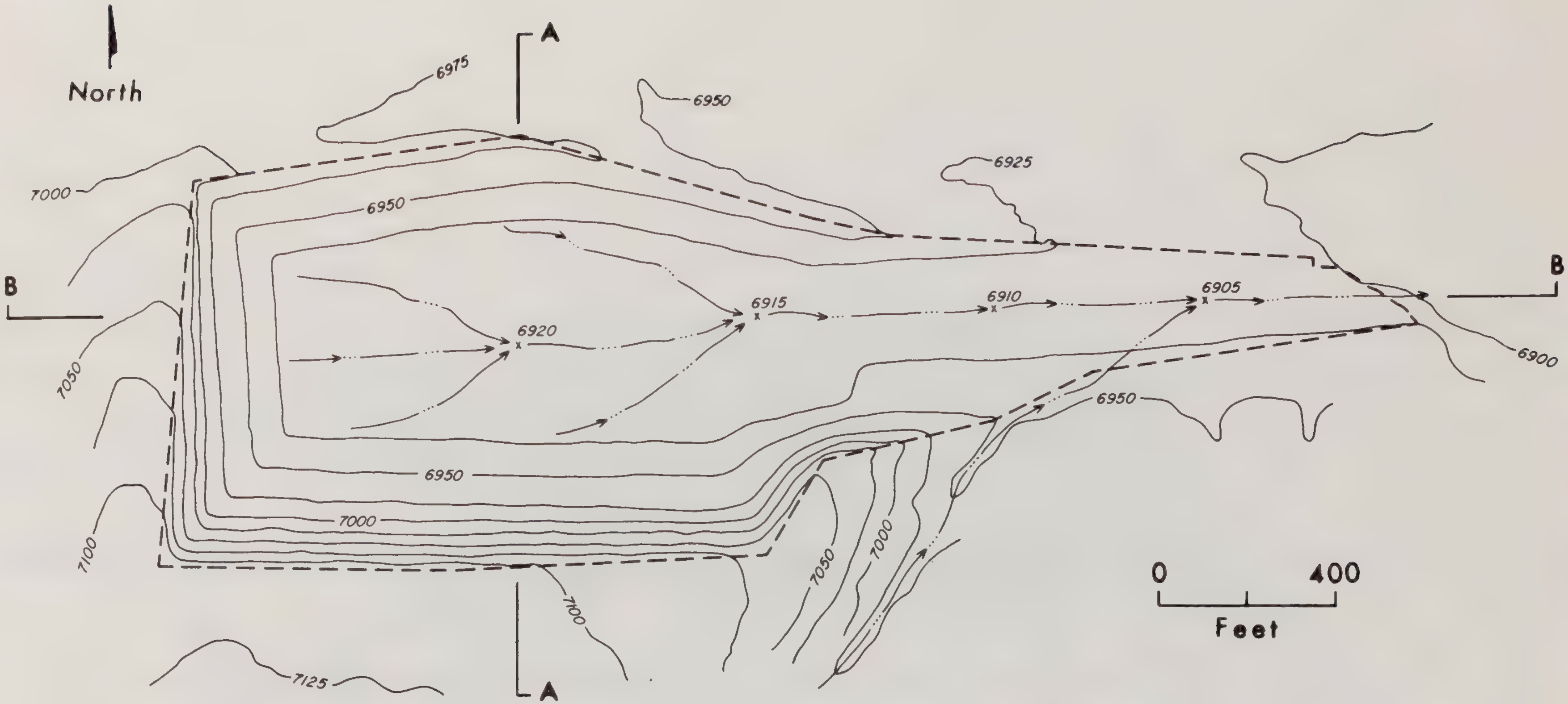



**Figure 7-13-1**
**Plan View of the Reclaimed Phase II Open Pit**

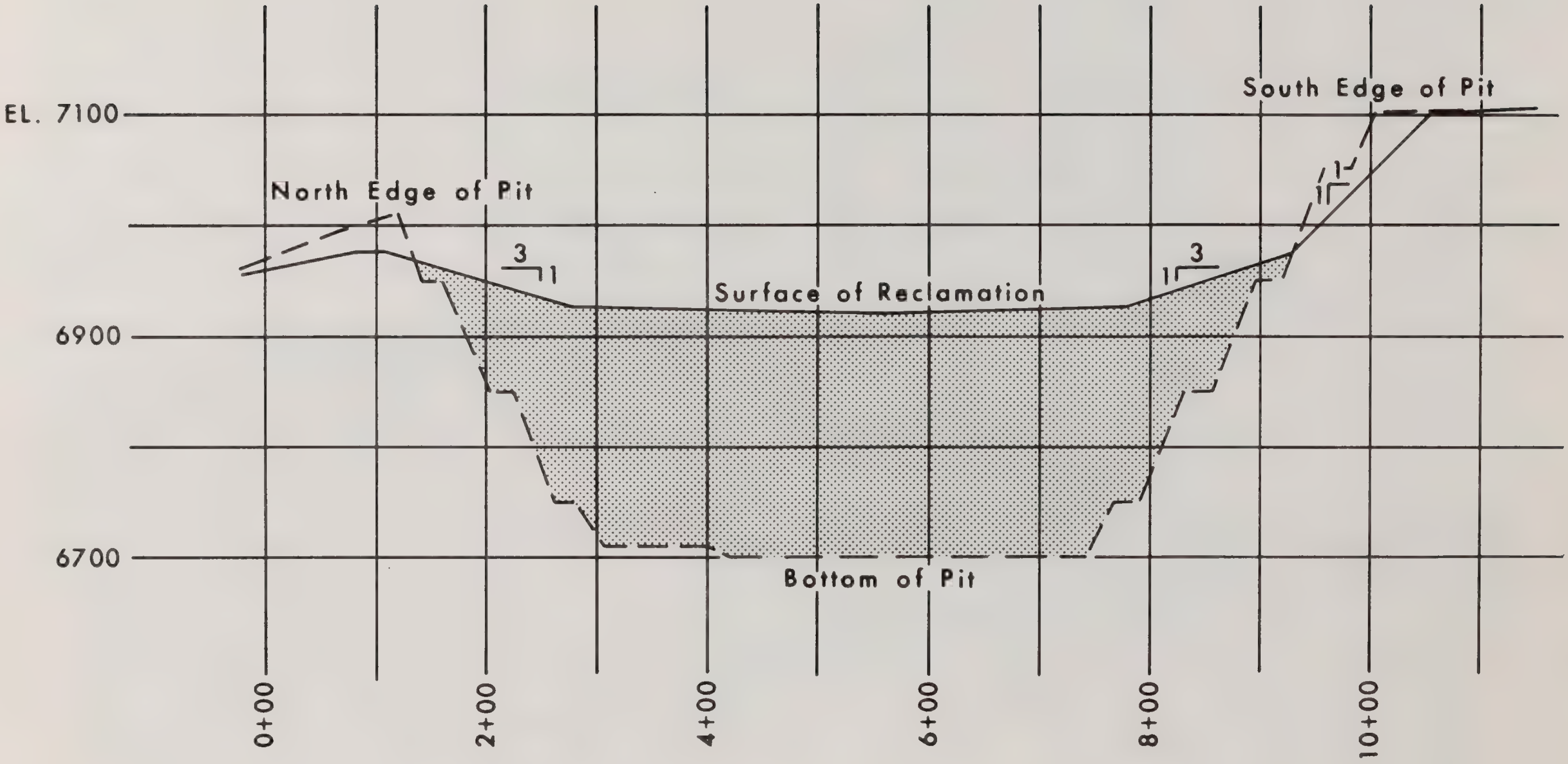



Figure 7-13-2
Section A-A of the Reclaimed Phase II Open Pit

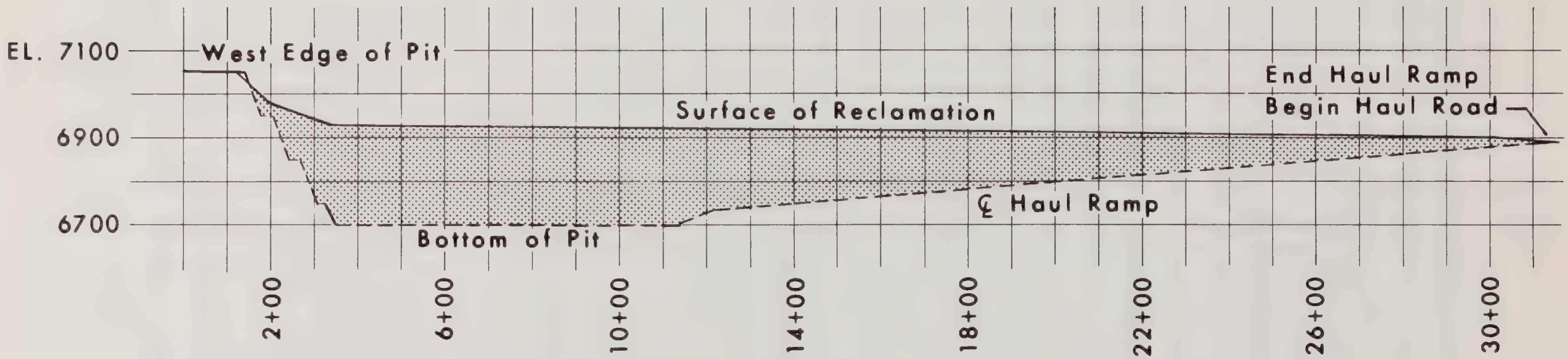



Figure 7-13-3
Section B-B of the Reclaimed Phase II Open Pit

The operational slopes on the west and south walls of the pit will be reduced from 60° to 45°. The material excavated from the pit walls during highwall reduction will be graded to 3:1 slopes away from the highwall toward the center of the pit. The north and east sides of the pit will be reduced to 3:1 slopes as shown on Figure 7-13-2. Drainage from the east gulch fill area will drain into the re-established pit drainage system which continues into Dry Fork Gulch.

The south and west highwall crests will be rounded to eliminate a sharp edge where erosion could occur. In addition a water diversion ditch will be constructed above the south highwall thereby diverting runoff into the adjacent draw to the east. The 1:1 rock slopes on the west and south walls of the pit will be abandoned as barren rock slopes. The remainder of the open pit area will be topsoiled and revegetated as outlined in Section 7, Chapter 8.

The existing flow in the Upper Aquifer is due to fractures in the stratigraphy. Therefore, reestablishment of the upper aquifer will be accomplished with overburden fill. The reestablished aquifer will have higher flow characteristics than currently exists due to the increased fracturing resulting from blasting and material handling. The infiltration, soil moisture, and runoff producing characteristics of the surface will approximate those of similar surrounding areas once grading, topsoiling, and revegetation have been completed (Section 7, Chapter 8).

## 13.4 PROCESSING FACILITY

The timing and details of the abandonment and removal of the Lurgi demonstration plant are also dependent upon the results of the project. At the termination of the project, the abandonment procedure would involve several stages.

- All tanks, aboveground structures and aboveground piping will be salvaged and removed. Maintenance shops and administration facilities will remain in place until the final stages of abandonment.

- All concrete structures will be demolished to grade level, and all concrete and asphalt surfacing, curbs, etc., will be broken up in place. Hard packed, unsurfaced or temporarily surfaced roads will be scarified and the tight surface broken up.
- Underground piping, culverts and drains will be plugged and abandoned in place. After the connecting pipes have been plugged, catch basins and manholes will be filled with earth.
- The rubble from all concrete foundations, pavements and other man-made features will be covered with approximately two feet of overburden and reclaimed cover material will be salvaged from fill areas and/or overburden stockpiles.
- All graded areas will be recontoured through slope rounding, cutting, filling and other techniques as discussed in Section 7, Chapter 8. Dams will be removed, ponds and ditches filled or reshaped, and the land generally restored to blend with the surrounding topography. The area will then be revegetated in accordance with the principles established for revegetation in that chapter. All these activities will be designed to reclaim all affected land to a usable and productive condition equal to pre-existing land uses in the area and compatible with adjacent undisturbed areas.

## 13.5 PROCESSED SHALE DISPOSAL AREA

The processed shale disposal area will be designed to minimize any long-term adverse environmental impacts. Some of the mitigation measures incorporated into the design of this area include:

- Retaining dikes constructed of overburden material that will provide physical stability
- Isolation of the containment area from the ground water by constructing the disposal area on a ridge top as opposed to a valley

Abandonment of this area will, as an example, incorporate the following activities.

- Grading to provide drainage without causing accelerated erosion.
- Placement of subsoil materials to form a barrier to the upward migration of salts.
- Replacement of topsoil.
- Completion of revegetation efforts and removal of irrigation facilities and temporary fencing.
- Reclamation of access roads (roads which will not be left for public use) and revegetation of the last remaining disturbed areas.
- Reshaping and revegetation of all ponds, ditches and/or dikes associated with the disposal area.

All of these techniques are discussed in detail in Section 7, Chapter 8.

## 13.6 OIL SHALE AND OVERBURDEN AREAS

The low-grade oil shale and some overburden will be incorporated into the dikes constructed to contain the processed shale. This material will be reclaimed as part of the processed shale disposal areas. The locations of the low grade oil shale within the dike will be recorded so that it may be recovered in the future if it becomes economically viable to process it.

The overburden not incorporated into the dikes will be returned to the pit, graded, topsoiled, and revegetated as described in Chapter 8.

The overburden storage areas and the locations utilized for temporary oil shale storage will be graded to conform with the surrounding topography, topsoiled, and revegetated. All drainage control facilities will be regraded to approximate original contour and reclaimed.

## 13.7 SUPPORT FACILITIES

The support facilities will be abandoned in the same sequence as described above for the oil shale processing facility. If requested by the OSO and/or the BLM, some facilities may be left in place for future use such as:

- Selected monitoring and/or injection wells
- Sediment control structures and portions of the drainage control system
- Roads and/or trails
- Selected pipelines and/or power lines

The determination of the facilities to remain will be made prior to the outset of the detailed planning of the abandonment activities to ensure that the desired facilities are not inadvertently destroyed.

The haul road from the mine to the Lurgi processing area will be abandoned to a reclaimed topography depicted on Figure 7-13-4. The portion of the haul road cut through solid rock will remain with 1:1 rock slopes. The portion of the road which was constructed of fill material will be reclaimed to 3:1 slopes with the majority of the fill material material being used to backfill the open pit. These slopes will be topsoiled and revegetated as described in Section 7, Chapter 8.

Portions of the access roads, to be designated after consultation with the OSO and the BLM, will be left intact after abandonment. These roads will be used for public access to areas where public access was interrupted by the mine and mine related activities.

Monitoring equipment will be removed and the sites reclaimed after data collection is complete. The casings for monitoring wells will be cut back to the surface and plugged with concrete, from bottom to top.

The reinjection wells may be left intact for monitoring purposes if requested by the OSO and/or BLM. These wells will also be cut back to ground level and plugged once they are no longer required.

Most drainage control facilities will be obliterated and drainage systems conforming to the surrounding topography established. The dams associated with sediment control reservoirs will be breached and graded. The ditches will be leveled and runoff allowed to follow the natural drainages. Check dams and terraces will be utilized if necessary for erosion control.

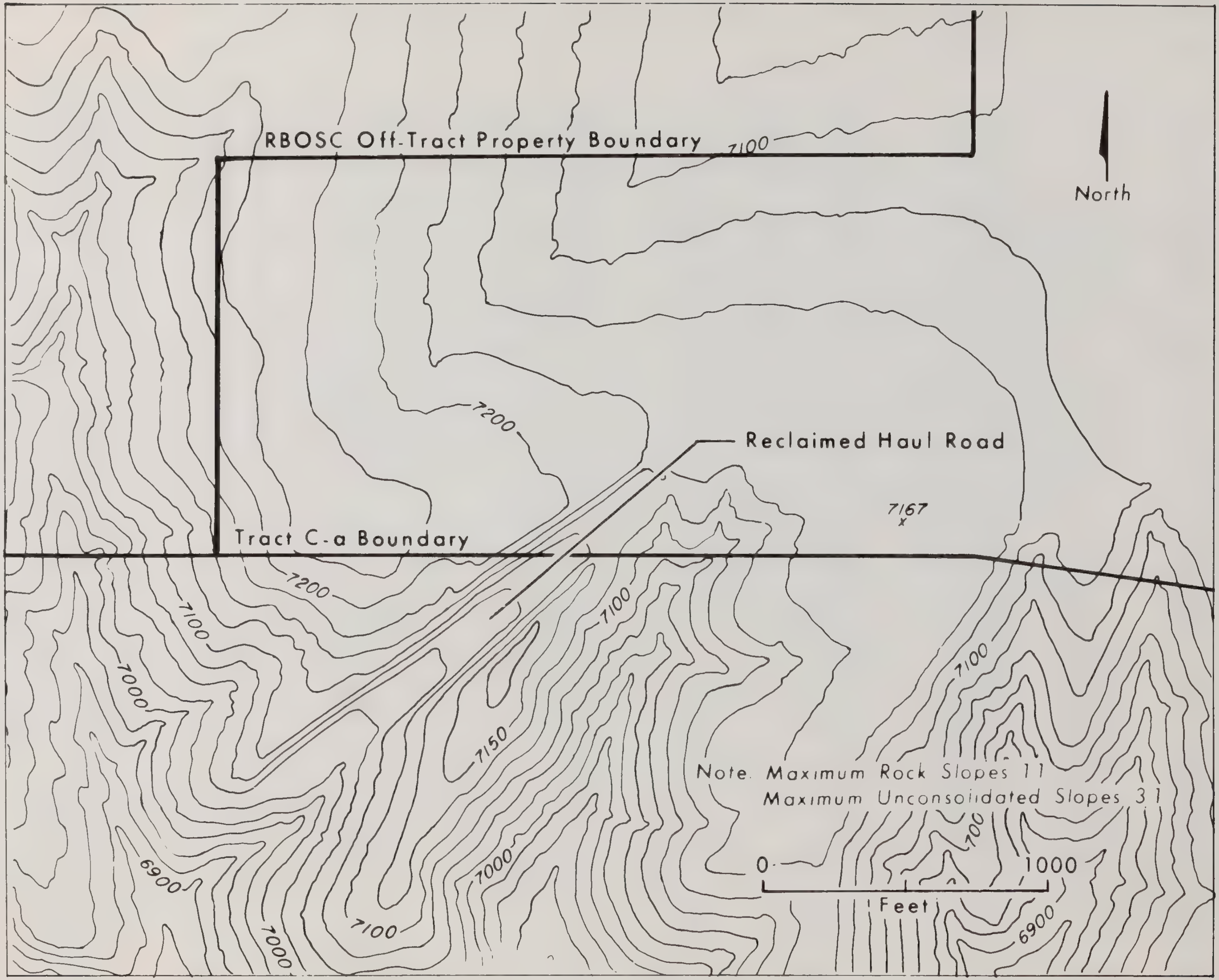



Figure 7-13-4
Topography of Reclaimed Haul Road From Mine to Lurgi Processing Facilities

# Section 8

# ENVIRONMENTAL ASSESSMENT

# CHAPTER 1
# INTRODUCTION

RBOSC's proposed Lurgi Demonstration Project involves many of the same activities and types of facilities as the MIS Project, and the proposed sites of the Lurgi processing facilities and open pit mine are near the MIS facilities. Consequently, the potential environmental impacts of the proposed Lurgi Demonstration Project are expected to resemble the potential impacts of the MIS project in terms of both the nature and location of impacts. The insights gained from the MIS impact assessment were, therefore, used as the basis for the assessment of impacts for the Lurgi Demonstration Project.

The procedures employed in identifying, assessing, mitigating and monitoring of environmental impacts associated with RBOSC's ongoing MIS oil shale retorting project included the following elements:

- Identification of sources and nature of potential impacts
- Identification of environmental variables likely to be impacted
- Assessment of probable impacts without mitigation measures
- Formulation of impact mitigation measures
- Assessment of probable impacts with mitigation measures (net impact)
- Implementation of mitigation measures
- Design of monitoring program
- Assessment of actual net impacts (implementation of monitoring programs)
- Evaluation of success of mitigation measures, and reformulation if necessary

The basic tool of the process was a cause-and-effect matrix (Leopold et al. 1971). This matrix was used to identify potential impact sources, identify environmental variables likely to be impacted, and assign ratings reflecting the importance and anticipated severity of environmental impacts. This assessment was performed by an interdisciplinary group of specialists in project design and environmental concerns. Following this initial impact assessment, mitigation measures were proposed for significant impacts, and net impacts were assessed based on the anticipated results of such mitigation. Impacts which could be efficiently monitored were identified, and a monitoring program was designed. The monitoring program is a continuing RBOSC effort to evaluate the effectiveness of the MIS impact mitigation measures. A detailed description of the MIS impact assessment process is found in the Revised Detailed Development Plan for the MIS project (RBOSP 1977a).

The cause-and-effect impact assessment matrix developed for the MIS project was not reproduced during the Lurgi impact assessment, but rather the outputs of the MIS matrix were modified to reflect differences between the two projects. The result was an assessment of the probable environmental impacts, without mitigation measures, of the proposed Lurgi Demonstration Project. Mitigation measures were developed to reduce these impacts, again relying heavily on experiences with MIS. A detailed description of these mitigation measures is presented in the environmental protection portions of Section 7 of this DDP modification. Based on these mitigation measures, the probable net impacts of the Lurgi Demonstration Project were assessed. These net impacts are the principal subject of this section (Section 8), though some discussion of mitigation measures is necessarily included. Section 9 addresses the monitoring programs designed to measure the actual net impact of the proposed Lurgi project.

The following five chapters discuss the impacts of the Lurgi Demonstration Project on the air quality and meteorology, terrestrial ecology, aquatic ecology, hydrology and cultural resources of the Tract C-a area. In each chapter, impacts are addressed as to their source, and are described as to extent and ecosystem components likely to be affected. Brief summaries of the impacts discussed in each chapter are included in this introduction.

Air quality dispersion modeling results show that no Federal and State Ambient Air Quality Standard (NAAQS) or Colorado ambient standards will be exceeded due to air quality impacts from the Lurgi Demonstration Project. Likewise, no applicable Prevention of Significant Deterioration (PSD) increments will be exceeded, nor will there be adverse visibility impacts either in the vicinity of the tract or at the nearest Federal Class I area, the Flat Tops Wilderness Area.

Impacts to the terrestrial ecology of Tract C-a and vicinity from project development will result from the following sources: construction, mining, operations, storage and transfer, disposal and secondary (manpower-related) activities. Several of these activities will involve destruction of terrestrial habitat, resulting in species mortality and displacement. In addition, necessary fencing of operations areas will cause habitat to be functionally destroyed, as the carrying capacity of such areas will be lost for the duration of the project. Vegetative productivity of terrestrial habitats adjacent to developed areas may be decreased somewhat due to fugitive dust emissions associated with project activities. The noise levels produced by project-related activities may adversely impact the breeding success of terrestrial species and diminish animal numbers in the immediate vicinity of activity. Species which are expected to be most affected by these impacts include mule deer, avifauna, small mammals, feral horses and domestic livestock.

Only minor impacts to the aquatic communities are expected from project development. Construction activities may cause aquatic community changes due to habitat alterations or increased sedimentation; however, these impacts will be limited to communities on or near the tract. Mine dewatering will decrease some stream flows. These decreases in flow will result in localized impacts to periphyton and benthic communities in such areas. Additional impacts which may occur from periodic discharges into Corral Gulch include erosion of stream banks and scouring of the stream bottom near the points of discharge. No adverse effects to aquatic organisms from leachate are expected, as RBOSC is designing a processed shale disposal facility that will contain all leachate from the processed shale.

Major hydrology impacts could result from water consumption, an expanded cone of depression, sediment laden discharges and spills or leaks of contaminated water or products. The water management plan emphasizes recycling of water to minimize consumptive use. Excess mine seepage will be reinjected into the existing MIS injection system to contain the cone of depression to the south and east of the open pit site. Numerous detention ponds will be constructed to remove sediment from surface runoff. Spills and/or leaks of contaminated water or products which could cause adverse hydrologic impacts will be prevented by the measures described in Section 7, Chapter 7 - Oil and Hazardous Material and Waste Control.

Only two minor sites identified by a 100 percent survey of the cultural resources of Tract C-a and vicinity will be directly impacted by the Lurgi Demonstration Project. Based on the results of this survey and determinations issued by the BLM and the State Historic Preservation Office, no adverse impacts to significant cultural resources are anticipated as a result of the project.

CHAPTER 2

ENVIRONMENTAL SETTING

AND WILDLIFE INVENTORY

This chapter presents a summary of the physical characteristics and environmental setting of Tract C-a and vicinity as required by the Code of Federal Regulations 30 CFR 231.10 C (2). The physical and biological components of Tract C-a and vicinity were thoroughly studied and described during extensive baseline studies conducted from 1974 to 1976. Progress reports were published on a quarterly and annual basis during this period. Complete descriptions of the topography and geology of Tract C-a and vicinity appear in RBOSP Progress Report 5 (RBOSP 1975). Discussions of the hydrology, atmospheric conditions, aquatic ecology, terrestrial ecology and cultural resources of Tract C-a and vicinity are included in the "Final Environmental Baseline Report for Tract C-a and Vicinity" (RBOSP 1977b) and RBOSP Progress Report 10 (RBOSP 1977c).

The Lurgi Demonstration Project will encompass areas within and outside of Tract C-a, as described in the Project Overview (Section 1, Chapter 1). These combined areas are referred to as the "Lurgi Demonstration Project Area" or "project area" and are shown in Figure 8-2-1. While most of the information on the environmental setting presented in this chapter is based on the results of studies which were directed at Tract C-a, most of these studies encompassed a buffer zone which included the off-tract lands involved in the Lurgi project. Information which is applicable only to Tract C-a is identified as such, though such information may be expected to hold true for the off-tract portion of the Lurgi Demonstration Project as well.

## 2.1 TOPOGRAPHY AND GEOLOGY

A. Topography and Cultural Features - The project area is situated on the west flank of the Piceance Creek basin about 5 miles east of the Cathedral Bluffs. As defined here, the Piceance Creek Basin includes an area of approximately 1,600 square miles that is bounded on the north by

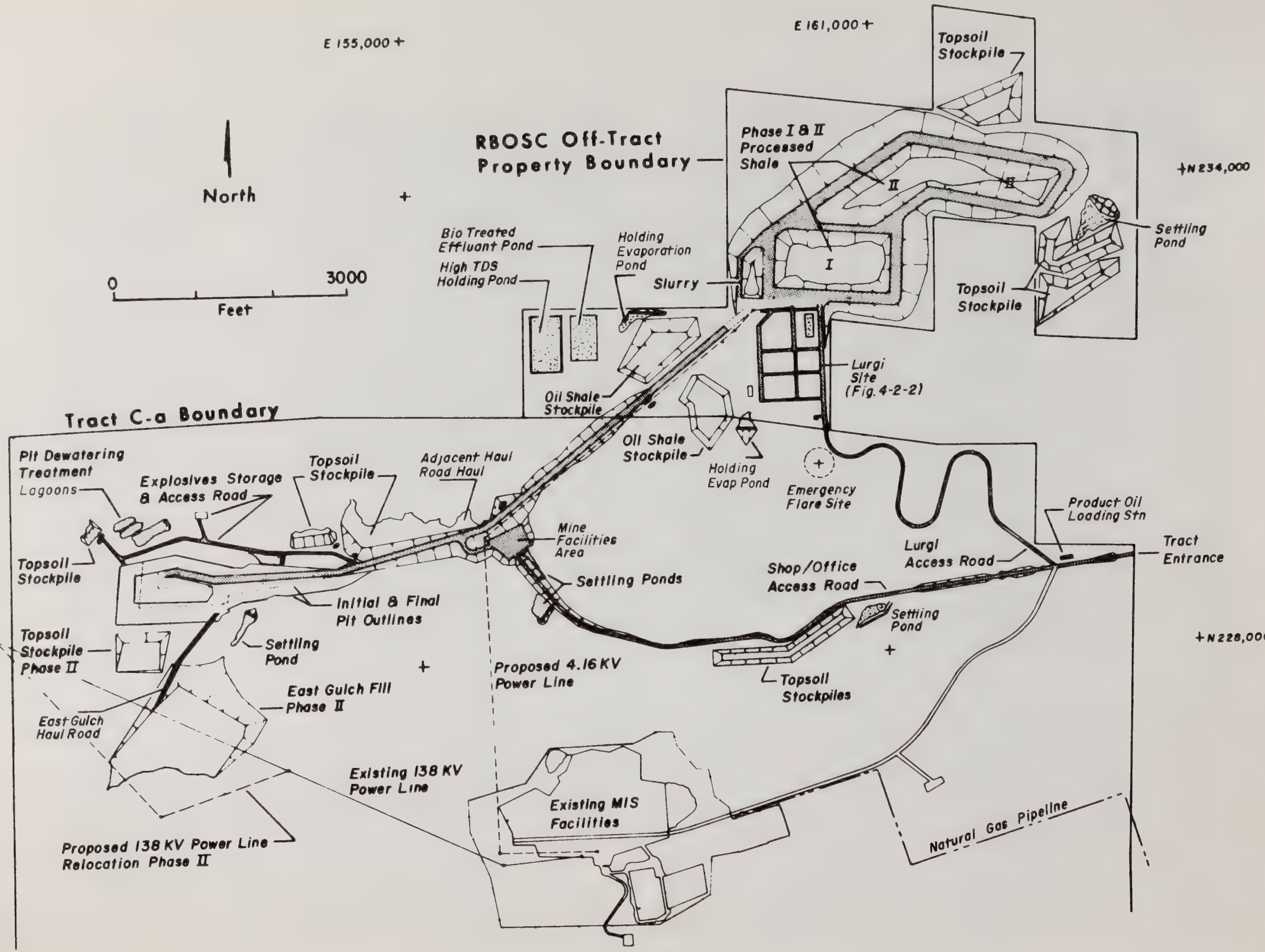



Figure 8-2-1
Lurgi Demonstration Project Plot Plan

the White River, on the east by Government and Sheep Creeks, on the south by the Colorado River and Roan Creek and on the west by Douglas Creek.

The Piceance Creek basin is part of the Colorado Plateau physiographic province. Because the basin was subjected to vertical uplift in relatively recent geologic time, it now appears as a large shallow bowl lying atop the Roan Plateau. The edges of the basin lie near the rim of the plateau and, as a result, streams draining the exterior faces of the plateau are short, few in number, and have steep gradients. The streams which drain the interior of the basin have longer and more gently sloping gradients.

The basin's topography is dominated by nearly parallel ridges and valleys running along a north-south or northeast-southwest axis. South-facing slopes are typically steeper than north-facing slopes. Valley floors tend to be narrow; ridges are broad and rounded. Most ridges are between 200 and 600 feet high, the average being about 300 feet. Piceance Creek, Yellow Creek and tributaries of Douglas and Sheep Creeks drain the northern part of the basin and are tributaries of the White River. Parachute Creek, Government Creek and Roan Creek drain the southern part of the basin and empty into the Colorado River.

Surface elevations near the project area vary from about 6,600 feet in Corral Gulch near the northeast corner of Tract C-a to slightly more than 7,400 feet on Airplane Ridge near the southwest corner of the tract. The project area is drained by Big Duck Creek and Corral Gulch. Big Duck Creek flows into Yellow Creek about 7 miles northeast of the project area. Corral Gulch joins with Box Elder Gulch and Stake Springs Draw to form the headwaters of Yellow Creek. Yellow Creek flows northeast from its origin but eventually curves to the northwest before emptying into the White River about 20 miles north of the project area at an elevation of approximately 5,500 feet. The other major drainage near the project area is Ryan Gulch, which flows about 2.5 miles south of Tract C-a before joining Piceance Creek about 10 miles due east of the project area.

Man-made features occurring on or near the project area are primarily related to oil shale development. The major man-made feature in the area is RBOSC's

MIS facility with its associated structures, roads, pipelines, ponds, etc. The abandoned Shields-Caldwell Hunting Camp near the confluence of Corral Gulch and Dry Fork is located on Tract C-a and has been converted to office space for the construction contractor. The only occupied dwellings in the vicinity are at the Reagle Ranch headquarters on Ryan Gulch about 3 miles southeast of the tract.

Additional developments in and around the project area include numerous primitive roads and trails; a gas pipeline which crosses the southeast corner of Tract C-a, then parallels Stake Springs Draw for several miles before crossing the Cathedral Bluffs; a power transmission line located about 5 miles west of the project area; several miles of fence at various locations; and several improved springs, check dams and small reservoirs. The nearest paved road is Rio Blanco County Road 24 which leads into the northeast corner of Tract C-a. The only paved highways in the vicinity are the Piceance Creek road to the east, the Douglas Pass road (State Highway 139) to the west and State Highway 64 between Rangely and Meeker to the north. There are also several conventional natural gas wells immediately west of Tract C-a. Tract C-a is overlain by oil and gas leases, and is part of the USGS Sagebrush Hills Oil and Gas Unit.

B. Geology - The geology of the project area was analyzed using current aerial photography, photogeologic mapping, surface geologic mapping, core hole drilling, laboratory analyses and data compilation. These techniques provided the resource data for the following discussions of stratigraphy, structure and overburden.

1. Stratigraphy - Only the stratigraphic intervals pertaining to development of the Lurgi Demonstration Project, namely, the oil shale-bearing Green River Formation and the overlying Uinta Formation, are discussed below.

The oil shale underlying the project area was deposited in the eastern portion of ancient Lake Uinta during Eocene time. The term "oil shale" is actually a lithologic misnomer because the rock is not shale nor does it contain oil in the conventional sense. Most oil shale is dolomitic marlstone containing variable amounts of organic matter (kerogen) derived chiefly from algae, aquatic organisms, waxy spores and pollen grains. This organic matter is only slightly soluble in ordinary petroleum solvents, but a large part can be converted to synthetic oil by destructive distillation.

Figure 8-2-2 is a generalized stratigraphic column of Eocene rocks in the Piceance Creek basin showing the relative position of the major Eocene units, the interval containing oil shale and several key stratigraphic markers. Several of the key stratigraphic markers provide convenient boundaries which segregate major lithologic units within the project area. The area between the Orange marker and the Blue marker on Figure 8-2-2 represents the uppermost part of the Douglas Creek-Garden Gulch Members (undifferentiated) and consists mainly of light gray to brownish gray oil shale with lesser amounts of gray shaley siltstone. The overlying interval from the Blue marker to the A-groove is the main oil shale deposit of the lower Parachute Creek Member of the Green River Formation, which consists mainly of dolomitic marlstone with varying amounts of kerogen. The upper part of the Parachute Creek Member above the A-groove is mainly light gray to medium brown oil shale grading upward into light gray barren marlstone interbedded with gray siltstone and fine-grained sandstone. The overlying Uinta Formation covers most of the project area's surface and consists mostly of brown to light brown fine-grained massive sandstones with lesser amounts of siltstone.

Based on a subsurface correlation network, an oil shale zonation was established within Tract C-a. This zonation resulted in the delineation of 19 zones, 9 relatively rich and 10 relatively lean. Figure 8-2-3 depicts a core hole histogram cross section of Tract C-a showing the alternating rich (R-0 through Mahogany and R-8) and lean zones (L-00 through L-8).

Acid-extractable alumina is present in all 19 rich and lean oil shale zones. United States Bureau of Mines (USBM) x-ray diffraction analyses of core samples show that dawsonite and nordstrandite occur in a stratigraphic interval from the upper part of the R-2 zone through the lower part of the R-5 zone. Analcime occurs stratigraphically above and below the dawsonite-bearing interval.

Within Tract C-a, limited amounts of nahcolite occur as thin beds, stringers, nodules and coatings or small crystal growths on both vug walls and shale

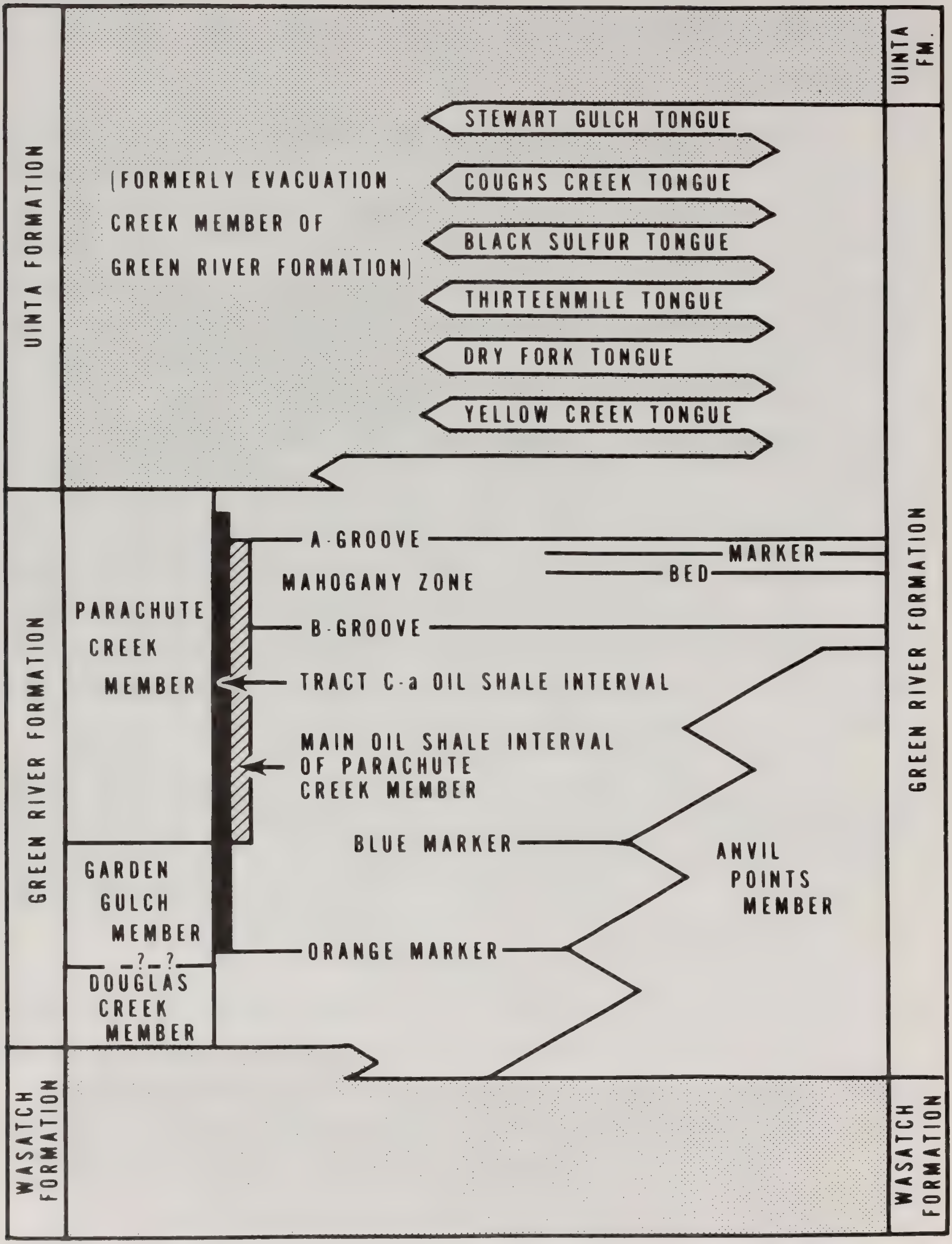



Figure 8-2-2
Generalized Stratigraphic Column of Tertiary Eocene Series, Piceance Creek Basin

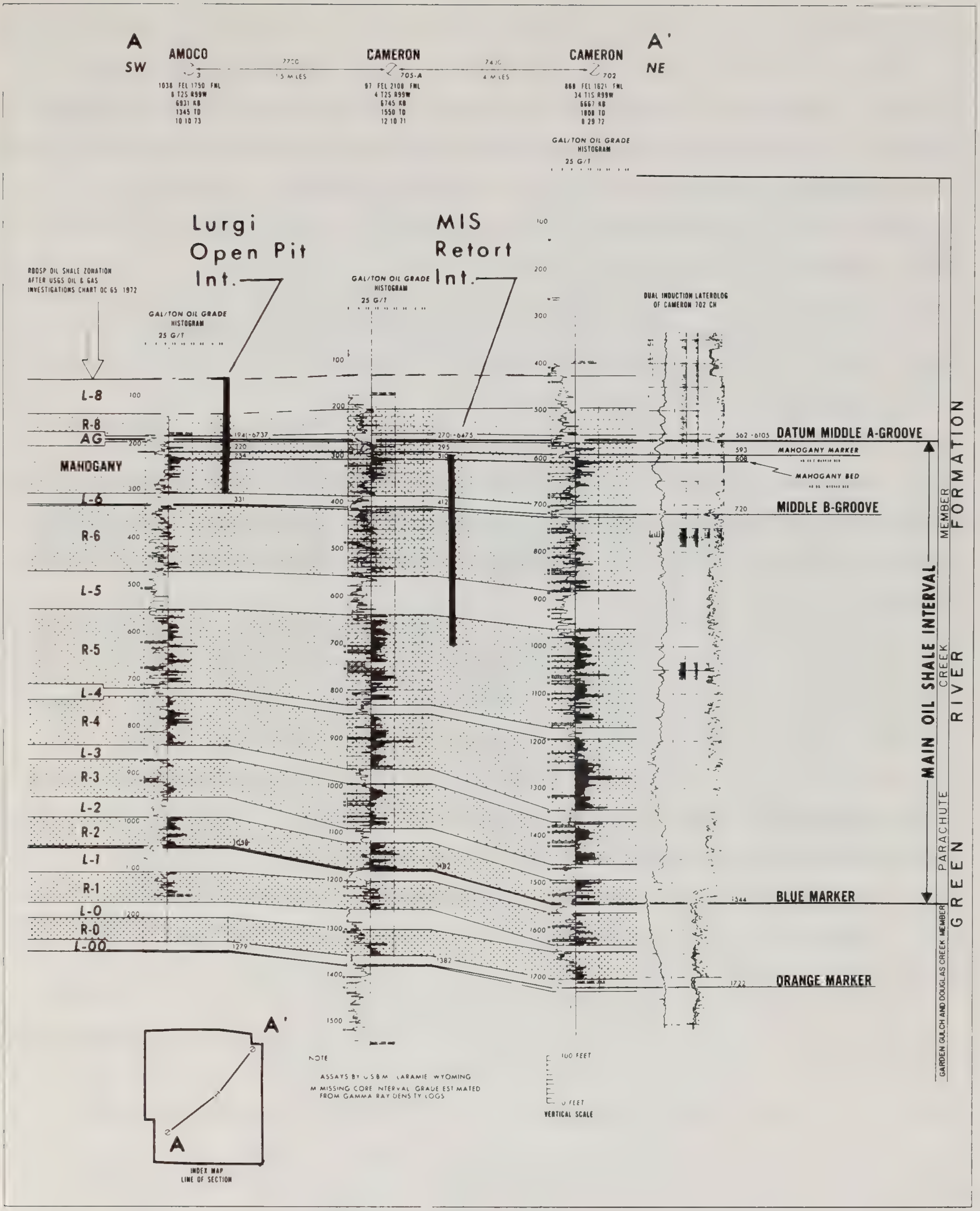



Figure 8-2-3
SW-NE 3-Core Hole Histogram Cross Section, Tract C-a

partings. The few scattered beds are usually less than 1 foot thick with a maximum thickness of 2 feet. Primary deposition of nahcolite within Tract C-a was apparently limited to nodules and a few relatively thin beds and stringers. Subsequent removal of the water-soluble nahcolite by ground water leaching has considerably reduced its original concentrations within the tract and resulted in many vugs or solution cavities. As a result, the limited amount of nahcolite remaining in the Tract C-a oil shale interval has little commercial value.

Methane and hydrogen sulfide have been detected in the oil shale sections within Tract C-a. The gases are probably trapped in vugs and fractures as well as dissolved in the ground water.

Trace elements analyses of fresh shale, processed shale (Fischer Assay residue), and fresh overburden were conducted. Quantitative analyses of trace elements were run for antimony, arsenic, boron, cadmium, fluorine, mercury and selenium. Antimony, mercury and selenium concentrations averaged about one part per million (ppm); arsenic and cadmium averaged a few ppm; and boron and fluorine averaged a few hundred ppm. The results of these trace elements analyses are presented in detail in RBOSP Progress Report 5 (RBOSP 1975).

2. Structure - The Piceance Creek basin is a broad northwest-southeast trending structural trough, the central portion of which is underlain by the Green River Formation in an area approximately 60 miles long and 40 miles wide. Green River Formation sediments around the basin's periphery have been removed by erosion.

Beds within the project area strike generally to the north and dip basinward to the east and northeast at about 200 to 350 ft/mi (2-4°) except where locally disturbed by folds and faults. The structural framework of Tract C-a and vicinity is dominated by the Sulfur Creek anticline and three major en'echelon fault systems (graben) on its northeast flank. Four minor folds and multiple subsidiary faults complete the framework.

Figure 8-2-4 is a map of the middle A-groove showing the structural features of Tract C-a and vicinity. The Sulfur Creek anticlinal nose is a gentle low relief structure which plunges southeastwardly through the southern portion of the tract. The three northwest-trending en'echelon grabens essentially parallel the Sulfur Creek anticlinical axis. The northernmost graben is the most structurally complex of the three. The combination of cross faulting within this graben with differential displacement on the graben-bounding faults provides strong evidence that the graben is not a single downthrown block, but rather a series of broken and tilted (rotated) blocks. Surface fault displacements on Tract C-a range from a few feet to more than 230 feet.

A joint system consisting of three main joint sets is present within Tract C-a with joints in each set generally spaced 10 feet or more apart. The dominant set strikes N56°-76°W with dips of 74°SW passing through vertical to 86°NE. The secondary set strikes N28°E with a dip of 80°NW. The tertiary set strikes N15°W with a dip of 75°E. These joint set orientations are average values for the entire tract. Some variations in these values occur locally.

3. Overburden - Overburden thickness between ground surface and the middle A-groove horizon varies considerably throughout the tract depending upon local changes in topography. Also, the general dip of the subsurface middle A-groove horizon results in an increase in overburden in the northeasterly direction. Overburden thickness ranges from about 60 to 875 feet with an average of about 480 feet for the tract. The least overburden is on the western edge of the tract in Dry Fork and Corral Gulch. The maximum overburden is near the tract's northern border atop the ridge due north of core hole G-S 4-5.

## 2.2 LAND USE

The principal current land uses in the Piceance Creek basin are ranching and stock grazing, big game hunting, conventional oil and gas field development and oil shale development. Haying is confined to drainage bottoms but stock grazing (primarily cattle) is conducted throughout most of the basin.

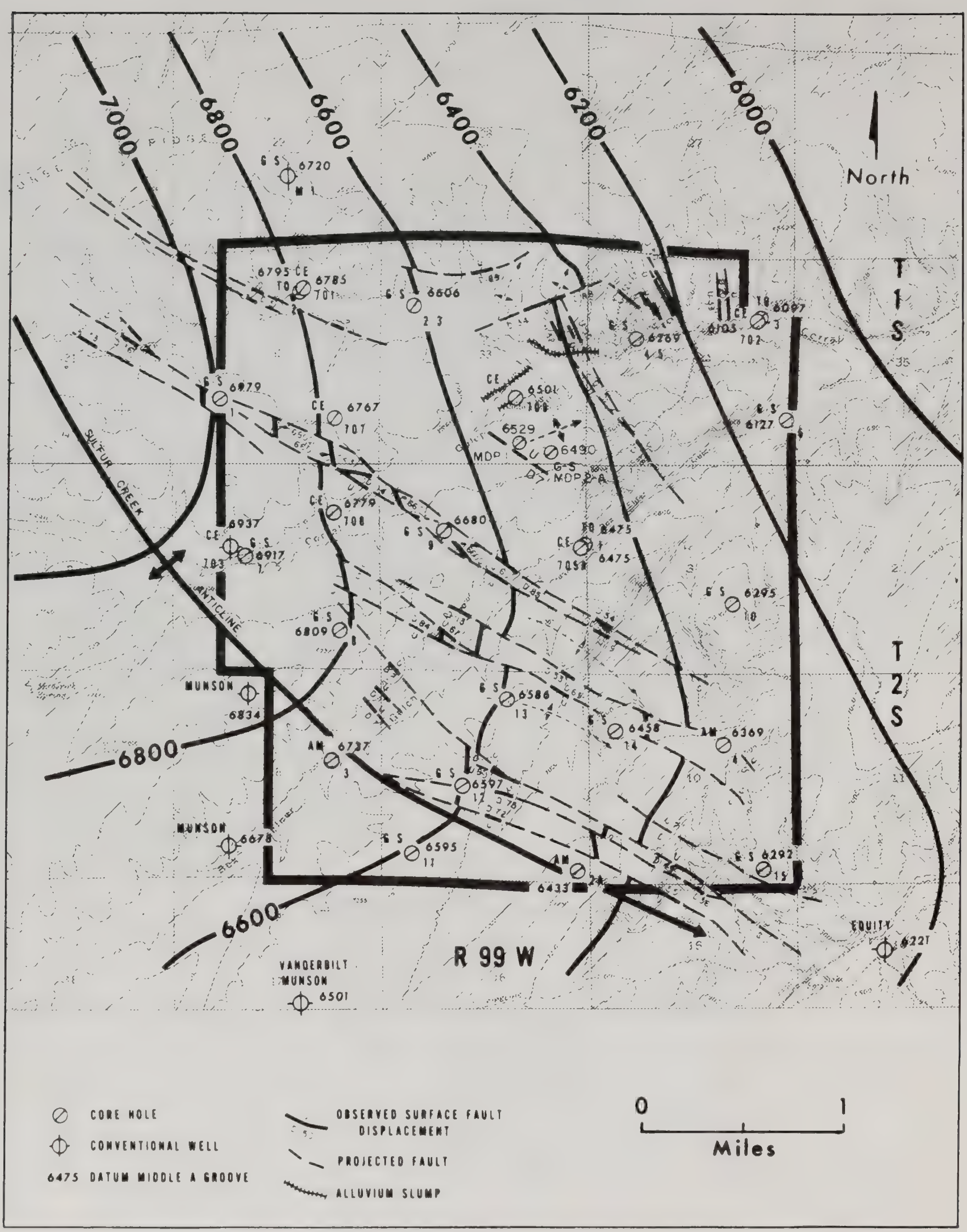



Figure 8-2-4
RBOSC Tract C-a Middle A-Groove Structure

Although the basin is relatively isolated and virtually uninhabited (except for the Piceance Creek valley), accessibility is good. Big game hunting in October and November is the major recreational use of the area. The project area is located in CDOW big game management Unit 22, one of the most popular deer hunting areas in the state. Unit 22 has been listed among the top ten (rank range from 1st to 9th) units in the state for the highest number of hunters and largest number of deer harvested for several years (Colorado Division of Game, Fish and Parks, 1971, 1972; CDOW, 1973, 1974, 1975, 1976, 1977, 1978, 1979). The following tables present harvest statistics for Unit 22 and the State of Colorado for the nine-year period, 1971-79.

TABLE 8-2-1

HARVEST STATISTICS FOR UNIT 22 AND THE STATE OF COLORADO FOR THE FIVE-YEAR PERIOD, 1971-75

| | Number of Mule Deer Harvested[1/] | | Hunter Pressure Expressed In Hunters per Square Mile | |
|---|---|---|---|---|
| Year | Game Management Unit 22 | State of Colorado | Game Management Unit 22 | State of Colorado |
| 1971 | 3,046 | 40,056 | 5.38 | 0.91 |
| 1972 | 5,446 | 66,109 | 7.27 | 1.24 |
| 1973 | 2,030 | 75,451 | 7.27 | 1.24 |
| 1974 | 1,982 | 54,142 | -- [2/] | -- [2/] |
| 1975 | 2,191 | 39,084 | 4.21 | 1.24 |

[1/] Data from Big Game Harvest Statistics published yearly by the Colorado Division of Game, Fish and Parks 1971 and 1972; CDOW 1973, 1974 and 1975. Includes all deer harvested exclusive of archery for 1971-1975.

[2/] Not listed for 1974.

TABLE 8-2-2

HARVEST STATISTICS FOR UNIT 22 AND THE STATE OF COLORADO
FOR THE FOUR-YEAR PERIOD, 1976-1979

| | Number of Mule Deer Harvested[1/] | |
|---|---|---|
| Year | Game Management Unit 22 | State of Colorado |
| 1976 | 2,599 | 41,145 |
| 1977 | 4,821 | 58,853 |
| 1978 | 7,383 | 78,428 |
| 1979 | 2,010 | 55,327 |

[1/] Data from Big Game Harvest Statistics published yearly by the Colorado Division of Wildlife, 1976, 1977, 1978 and 1979. Includes all deer harvested.

The harvest has fluctuated over the years. More non-residents than residents hunt in Unit 22. Limited elk hunting occurs west of the project area.

Small game and waterfowl in the vicinity of the project area are not as heavily hunted as big game animals. The small game animals harvested in the vicinity of the project area include the cottontail rabbit, mourning dove, sage grouse and blue grouse. Waterfowl hunters generally hunt Rio Blanco Lake, the White River and Piceance Creek and its larger tributaries, but seldom hunt near the project area. Most waterfowl harvested are migrants. Predator hunting of coyotes and, to a lesser extent, bobcats, is practiced in the area.

Because no fishery exists within or near the project area, and because the fish population of the White River below the confluence of Yellow Creek is generally limited to rough and forage species, there is essentially no human utilization of the aquatic biota of the area other than for scientific studies.

Trapping intensity varies, depending upon the price of the pelts. Limited trapping for a particular species occurs until prices paid for pelts reach a profitable level. Furbearers trapped near the project area are primarily limited to coyotes, bobcats and weasels on rare occasions.

Before enactment of the Wild Horse and Burro Act in 1971, some local ranchers occasionally captured feral horses. These animals are now fully protected by the BLM.

Other recreational activities in the Piceance Creek basin include snowmobiling; jeeping; hiking; hunting for gemstones, minerals and artifacts; scenic viewing from Cathedral Bluffs; observing wildlife; and short trips focused on appreciating the relatively remote and undisturbed character of the area. These activities are not as publicized nor as easily quantified as hunting; nevertheless, they represent additional uses of the area's resources.

While the Piceance Creek basin may be characterized as a relatively unspoiled natural setting, it is not characterized by particularly spectacular scenery, nor does it contain any exceptional natural, archaeological, or historical sites. The fact that the Piceance Creek basin is relatively unknown to tourists and others pursuing non-hunting outdoor recreational experiences is also attributable to the close proximity of the basin to many well known recreation areas such as:

- Dinosaur National Monument
- Black Canyon National Monument
- Flaming Gorge National Recreation Area
- White River National Forest
- Colorado National Monument

Residential dwellings are widely separated in this sparsely populated area. Most of the existing residences are associated with ranching and, to some extent, hunting. A hunting club once owned several permanent buildings on Tract C-a that were used during the big game season.

Prior to the arrival of white men, Ute Indians occupied the area. When white men settled the area, the Indians were forced to relinquish their holdings and the livestock industry became established. This industry continues to be of primary importance in the region. Three BLM grazing allotments have been established near the project area. They are composed of Federal, State (Division of Wildlife and state school), and private holdings.

Ranching requirements have led to changes in the fauna of the region. Large predators have been gradually eliminated or drastically reduced in numbers because ranchers felt that they affected the profitability of the livestock industry. Animals such as bears, cougars and wolves were systematically removed by trapping and bounty hunting. The American bison (buffalo), a native ungulate, was extirpated by uncontrolled hunting before the cattle industry began. Reintroduced in the early 1960's, buffalo proved to be incompatible with livestock interests. The herd of approximately 30 animals could not be contained by conventional fences and was consequently removed during 1973 and 1974.

A limited amount of vegetation modification such as sagebrush eradication by burning and aerial herbicide application has been used on public lands within the study area. Much of the private lands along streams to the southeast and northeast of Tract C-a have been converted to hay fields.

## 2.3 SURFACE AND SUBSURFACE HYDROLOGY

The Piceance Creek basin can be defined in terms of the geologic basin, which includes parts of Moffat, Rio Blanco, Garfield, Gunnison and Mesa counties; or the hydrologic basin, which encompasses a much smaller area than the geologic basin. The hydrologic basin covers an area of approximately 900 square miles and is bounded on the north by the White River, on the east by Colorado Highway No. 13, on the south by the Roan Plateau and on the west by Cathedral Bluffs (Figure 8-2-5).

Studies of the hydrology of Tract C-a and vicinity have been conducted since 1975 to determine quantity, quality and source of surface waters in the area and to identify the characteristics of subsurface water sources. These

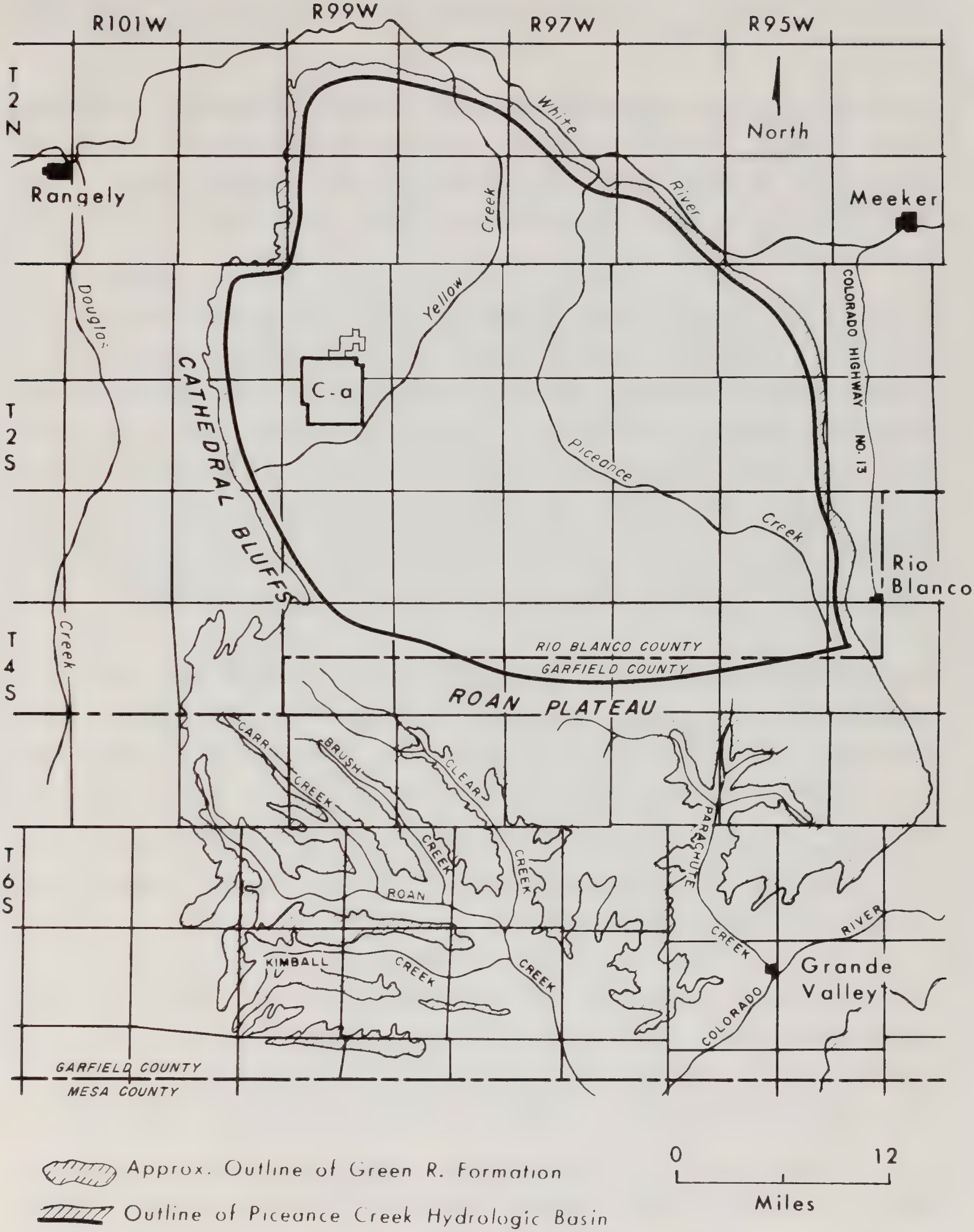



Figure 8-2-5
Piceance Creek Basin Hydrologic Basin

studies are critical to the assessment of development impacts on local and regional water supplies.

Hydrology conditions have been identified through studies of springs and seeps, streams, alluvial aquifers and deep bedrock aquifers. Complete descriptions of these conditions and complete data analyses appear in the RBOSP Final Environmental Baseline Report (RBOSP 1977a) and RBOSP quarterly progress reports.

The study area drainage system and the gaging stations at which surface water data were collected are shown in Figure 8-2-6. The drainage system flow is intermittent with a baseflow provided by springs. The flows from the springs generally disappear within a mile or two of each spring. Even during snowmelt runoff, the discharge from Corral Gulch has not proceeded more than a couple of miles down Yellow Creek during the monitoring record to date. The flow measured at the mouth of Yellow Creek is sustained from nearby springs. Peak stream flows usually occur after spring snowmelt (March - April) and low flows occur in late summer or early fall (August to November).

The gaging stations at Corral Gulch (east) and Yellow Creek have sustained a baseflow for the period of record, with Yellow Creek having higher discharges. The gaging stations at Box Elder and Corral gulch (west) have not sustained a baseflow. However, both have recorded run-off from snowmelt. Thirty-seven springs and seeps (Figure 8-2-7) were identified in the study area during Baseline Studies. These appear to be fed by alluvial or shallow bedrock aquifers or a combination of both. Detailed studies including water quality and quantity were conducted on six springs.

Along the stream reaches on Tract C-a, iron, pH and total dissolved solids (TDS) exceed Federal drinking water limits. Yellow Creek water quality is naturally saline, and White River water quality responds to the influx of Yellow Creek water as would be expected through proportioned mixing.

Three distinct ground water systems occur in the area: the surface alluvial aquifer, the upper bedrock artesian aquifer and the lower bedrock artesian aquifer. On Tract C-a, the alluvial aquifer is present along Corral Gulch,

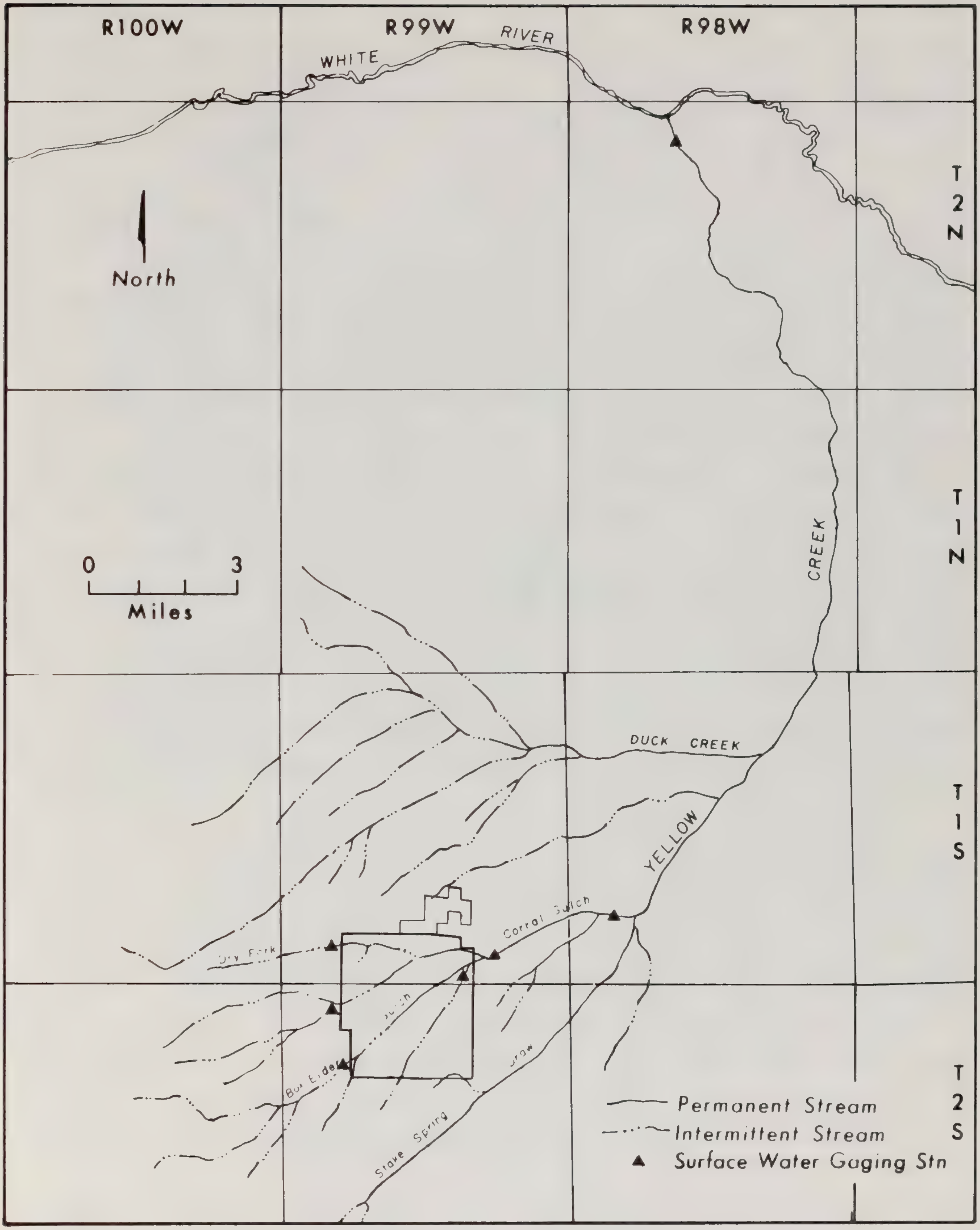



Figure 8-2-6
Yellow Creek Drainage Basin and Baseline Surface Water Gaging Stations


Figure 8-2-7
Locations of Springs and Seeps in the Study Area

Dry Fork, Rinky Dink Gulch and Box Elder Gulch, and is quite variable in thickness. The alluvial aquifer is hydraulically connected with the streams and thus shows seasonal variations. In general, the water quality of both the upper and lower aquifer decreases downgradient, having highest concentrations of dissolved minerals near the northeast corner of the tract.

## 2.4 CLIMATE AND AIR QUALITY

Meteorology and air quality studies have been conducted on Tract C-a since February 1975. Extensive meteorological and air quality measurements have been taken at several locations around the tract. Four sites were monitored during the baseline period (1975-1976) for background air quality and meteorology. Since 1977, three stations have been used to continue background monitoring and to measure impacts due to tract development. Complete descriptions of the RBOSC air monitoring network appear in previously published RBOSC reports. Monitored parameters include wind speed and direction, ambient air temperature, temperature differential, dew point, solar radiation, precipitation, carbon monoxide, oxides of nitrogen, nitric oxide, sulfur dioxide, hydrogen sulfide, ozone, total suspended particulates, noise and visibility. The results of these studies are presented in the RBOSP Final Environmental Baseline Report (RBOSP 1977b), and Modular Development Phase Monitoring Reports One (RBOSP 1977d), Three (RBOSC 1978), and Five (RBOSC 1979).

The general climate recorded on Tract C-a during the 5 years of studies completed to date agrees reasonably well with regional long-term conditions recorded at the National Weather Service Station in Grand Junction, Colorado. Climatic differences between the two locations are greatest for temperature and precipitation primarily due to variations in topography and elevation. The climate of the area surrounding the tract is similar to semi-arid steppe regions. Annual precipitation is approximately 10 to 12 inches, but is strongly dependent on local topography and elevation.

Since the entire Piceance Creek basin is surrounded by high mountains or ridges, many migratory low pressure systems are deflected around the region. Stationary high pressure cells often last for several days, because their passage is blocked by high mountains to the east. As a result, there is a high frequency of clear, sunny days, with high winds and large diurnal temperature changes. The prevailing westerlies of the atmospheric general circulation dominate the wind pattern year round, but are interrupted occasionally by the passage of frontal systems.

Air movements in the atmospheric boundary layer are affected by local topography. Wind velocities tend to be lowest at dawn, when there is little vertical thermal mixing and the lower surface air does not mix with the more freely moving upper air. During warm, sunny mornings, the laterally constricted, but vertically expanding air tends to blow up the valley. At night the process is reversed as the colder, more dense air at higher elevations drains into the depressions.

Tract C-a is in the Yampa Intrastate Air Quality Control Region (AQCR). EPA has classified each AQCR by attainment status for the criteria pollutants. The status for the area around Tract C-a for all criteria pollutants is classified as either "cannot be classified" (generally insufficient data), or "better than national standards". Air quality measurements indicated that the concentrations of most gaseous constituents are low, often near the lower detectable limits of the instruments. Ozone, hydrocarbons and particulates occasionally exceeded Federal and State ambient air quality standards during the baseline study. However, the ozone standard was increased by 50% in 1978, which is well above any ambient ozone measurement to date. The hydrocarbon standard was interpreted as a guideline, and there are serious technical reservations about the instrumentation used for monitoring. Consequently, hydrocarbon measurements were terminated shortly after the end of the baseline study. Finally, the occasional periods when the particulate standard was exceeded were due to natural conditions in the semi-arid region.

In general, visibility over Tract C-a is exceptionally good. Visual range averaged 80 miles during each of the study years.

Sound level measurements have shown relatively low levels of noise in the area surrounding the tract. Highest noise levels have been found in the immediate vicinity of the MIS processing area, but the influence of this activity on the general ambient noise levels decreases rapidly with increased distance from this area.

## 2.5 TERRESTRIAL ECOLOGY

Comprehensive, two-year terrestrial studies were initiated in October 1974 to inventory pre-development wildlife and assess and document baseline environmental conditions of the Tract C-a area. Results of this two-year study and extensive analyses of data collected during the study appear in the Final Environmental Baseline Report for Tract C-a and Vicinity (RBOSP 1977b). A complete description of methods used and results of the first year's study was published in the RBOSP Annual Terrestrial Baseline Report (RBOSP 1976a) and in previous RBOSP quarterly progress reports. All these reports are on file at the OSO. A summary of the terrestrial ecology of Tract C-a and vicinity follows.

A. Vegetation - A total of 13 vegetation types and/or associations (Table 8-2-3) have been identified in the study area. The majority of the study area (Tract C-a and a 5-mile perimeter on all sides) is occupied by pinyon-juniper and sagebrush vegetation types (68% of total area). Elevational ranges of these two types overlap, with sagebrush occupying the valleys, mesas, or gentle slopes having fine, deep soils; and pinyon-juniper occupying ridges and steep or rough slopes having coarse, rocky, or shallow soils (Table 8-2-3). Competitive interactions between the two types are most apparent where soil types and slopes intergrade.

The most extensive vegetation type in the study area is dominated by pinyon-pine and Utah juniper. The pinyon-juniper type occupies approximately 41% of the mapped portion of the study area. This type, as a whole, represents one of the most important vegetation types in the Tract C-a ecosystem because it provides a critical food supply and source of shelter for animals inhabiting the area during the winter, as well as providing reproduction areas, nesting sites and cover for summer inhabitants. During the baseline study period, percent cover in this type ranged from 4 to 9% in the shrub stratum and from 17 to 25% in the tree stratum; height of the tree stratum ranged from 3-7 m (10-22 feet)(RBOSP 1977c).

Table 8-2-3

GENERAL INFORMATION REGARDING VEGETATION TYPES AND ASSOCIATIONS SAMPLED IN THE TRACT C-a VICINITY DURING 1974-1976 FOR RBOSP

| Vegetation Type | Elevation | Exposure | Extent in Study Area | Soil Condition | Dominant Species |
|---|---|---|---|---|---|
| Aspen | 2435 m (8,000 ft) | north- and east facing | 961 acres (< 1%) | deep, sandy loams with large accumulations of organic matter | serviceberry sp<br>elk sedge |
| Douglas-fir | 2380 m (7,800 ft) | North- and east facing | 1,598 acres (1%) | shallow soils | Douglas-fir<br>serviceberry<br>snowberry<br>elk sedge |
| Mixed brush | 2100-2250 m (7,000-8,500 ft) | all slope aspects | 27,388 acres (25%) | deep, sandy loams and shallow soils above shale outcroppings | Utah serviceberry<br>big sagebrush<br>elk sedge |
| Pinyon-juniper woodland | 1950-2250 m (6,500-7,500 ft) | all slope aspects | 621 acres (< 1%) | Rentsac soil series | pinyon<br>juniper<br>sandberg bluegrass<br>slender wheatgrass |
| Pinyon-juniper mixed brush | 2100-2250 m (7,000-7,500 ft) | north- and south facing | 24,258 acres (22%) | Rentsac soil series | pinyon<br>juniper<br>Utal serviceberry<br>big sagebrush<br>sandberg bluegrass |
| Pinyon-juniper sagebrush | 1950-2250 m (6,500-7,500 ft) | all slope aspects | 20,288 acres (18%) | Rentsac soil series | juniper<br>pinyon<br>big sagebrush<br>sandberg bluegrass<br>slender wheatgrass |
| Sagebrush upland | 1950-2550 m (6,500-8,500 ft) | all slope aspects | 21,527 acres (20%) | Rentsac, Piceance, and Yamac soils series | big sagebrush<br>Douglas rabbitbrush<br>sandberg bluegrass<br>Hood phlox |
| Sagebrush bottomland | 1950-2550 m (6,500-8,500 ft) | all slope aspects | 7,262 acres (7%) | Glendive soils series | big sagebrush<br>Douglas rabbitbrush<br>western wheatgrass<br>Great Basin wildrye |
| Sagebrush greasewood | 1950-2550 m (6,500-8,500 ft) | slope aspects characteristic of study area drainages | 1,087 acres (1%) | alluvial soils | greasewood<br>big sagebrush<br>rubber rabbitbrush<br>cheatgrass<br>goosefoot |
| Sagebrush rabbitbrush | 1950-2550 m (6,500-8,500 ft) | slope aspects characteristic of study area drainages | 679 acres (< 1%) | alluvial soils | rabbitbrush<br>Great Basin wildrye<br>goosefoot<br>cheatgrass |
| Bald | 2170-2565 m (7,230-8,550 ft) | west facing | 2,087 acres (2%) | Rentsac soil series | Utah serviceberry<br>green rabbitbrush<br>sandberg bluegrass<br>slender wheatgrass<br>prairie junegrass |
| Shadscale | 1938-2045 m (6,460-6,810 ft) | steep south facing slope adjacent to major drainages | 1,280 acres (1%) | rock outcrops or very shallow soils | shadscale<br>big sagebrush<br>criogonum<br>fringed sagewort |
| Riparian | 1950-2250 m (6,500-7,500 ft) | all slope aspects | 185 acres (<1%) | wet | big sagebrush<br>water birch<br>quackgrass<br>Kentucky bluegrass |

The sagebrush type, occupying approximately 29% of the study area, is characterized by moderate cover (2 to 31%) and high density (2,981 to 9,633/ha) of big sagebrush in the shrub stratum and by an herbaceous stratum with high species diversity (up to 54 species) and cover from 15 to 50%. Mature trees are generally absent (RBOSP 1977a). The areal extent of the associations which comprise the sagebrush type is as follows: upland sagebrush, 20%; bottomland sagebrush, 7%; rabbitbrush, 1% and greasewood, 1%. The percent cover in the shrub stratum totals 39, 46, 40 and 44, respectively.

At the lower elevations of the study area, black greasewood becomes more abundant within the sagebrush type on saline alluvial soils. Shadscale occurs here as well as on alkaline south-facing slopes along major drainageways. Both black greasewood and shadscale occupy less than 2% of the total study area (Table 8-2-3).

The higher elevations of the study area support a mixed brush vegetation type. The type occupies moist north-facing slopes where winter snow accumulates, which are too cool for pinyon-juniper and too dry for aspen. The mixed brush type is characterized by the tall (1-3 m, 3-10 feet) life forms of three species; Gambel oak, Utah serviceberry and true mountain mahogany. Shorter shrubs (1m, 3 feet), consisting of big sagebrush and snowberry, coexist with the taller species. These species, with the exception of mountain mahogany and big sagebrush, form large patches due to clonal growth. The mixed brush type occupies approximately 25% of the mapped portion of the study area. The shrub stratum has an average combined cover of 57% ranging from 0.1% (gray horsebrush and pinyon-pine) to 27% (Utah serviceberry).

Aspen and Douglas-fir types (<1 and 1% of the study area, respectively) occur on the steep, generally north-facing slopes near Cathedral Bluffs, with aspen usually occupying slightly lower elevations than Douglas-fir. Ridgetops approaching Cathedral Bluffs support sagebrush which intergrades with the low drought-resistant grass and forb species of upland meadows.

Riparian vegetation types are uncommon (<1%) on Tract C-a and are restricted to small springs in open, alluvial bottomlands. Most of these areas (e.g. Stakes Springs) have been converted to pasturelands.

Other more typical riparian vegetation species such as water birch, willow and red osier dogwood are found adjacent to springs and seeps along steep draws. An example of an area in this vegetation type is Cottonwood Spring. It is not heavily grazed and contains a number of plant species which are unusual in the Piceance Creek basin (e.g., columbine, fowl mannagrass). A third type of riparian vegetation is found along drainageways of intermittent streams. This type generally contains species characteristic of the bottomland sagebrush association (e.g., big sagebrush, Douglas rabbitbrush, mountain snowberry, Sandberg bluegrass, Hood phlox and elk sedge).

The Lurgi plant site area is dominated by upland sagebrush and pinyon-juniper vegetation types. The open pit area is mainly vegetated by bottomland sagebrush and mixed brush.

Data on range production for the period from 1975 to 1979 are listed on Table 8-2-4. Production in the mixed brush habitat type is the highest of the three vegetation types sampled. A statistical comparison between 1978 and 1979 data indicates that there is no significant difference in total production for these years. Variations between 1979 and 1977 data are due primarily to an abundance of grasses produced in 1977. Statistical comparisons for earlier years are not appropriate because of variations in sample sites.

Relative to other habitats sampled, the sagebrush type exhibited intermediate production values for 1979. Production between years varied from 124 kg/ha in 1978 to 302 kg/ha in 1975. Statistical comparisons between 1978 and 1979 data indicated significantly higher production for 1979. In addition, production within caged plots was significantly greater than in unprotected plots in the upland sagebrush type for 1978 and 1979. Although direct comparisons with 1975 or 1977 data are not valid due to variations in sampling sites, it is evident that production vagaries among years are noteworthy. It is uncertain why large variations occur over a relatively short period (4 years). For whatever the reasons, naturally occurring perturbations in production make long-term predictions difficult, i.e. consider variations recorded for grasses and forbs within this vegetation type between sample years. Production of grass species during 1979 was 6 percent lower than that

TABLE 8-2-4

COMPARISON OF RANGE PRODUCTION (DRY WEIGHT, KG/HA) ESTIMATES OBTAINED ON AND NEAR TRACT C-a, 1975 THROUGH 1979[1/]

| Vegetation Type | | Production (dry weight, kg/ha) 1975 | 1977 | 1978 | 1979 |
|---|---|---|---|---|---|
| Mixed Brush | | | | | |
| Grasses | | | 165 | 97 | 109 |
| Forbs | | | 110 | 111 | 100 |
| | Totals | 233 | 275 | 208 | 209 |
| Pinyon-Juniper | | | | | |
| Grasses | | | 66 | 27 | 27 |
| Forbs | | | 9 | 16 | 17 |
| | Totals | 113 | 75 | 43 | 44 |
| Upland Sagebrush | | | | | |
| Grasses | | | 197 | 79 | 101 |
| Forbs | | | 18 | 45 | 35 |
| | Totals | 302 | 215 | 124 | 136 |

1/ The comparison is for the vegetation type in general. The same transects were not sampled during each period nor was the sample size equal.

of 1977, and 22 percent higher than production of 1978 (Table 8-2-4). Forbs exhibited an increase from 18 kg/ha in 1977 to 45 kg/ha in 1978, and decreased to 35 kg/ha in 1979.

B. Small mammals - Thirty species of small and medium-sized mammals occur in the vicinity of Tract C-a. Trapping results have been used to establish the distribution and abundance of small mammal populations on Tract C-a. Generally, vegetation types with the greatest amount of shrub cover (greasewood/sagebrush, rabbitbrush and mixed brush) exhibited the greatest apparent abundances of small mammals.

At elevations above 8,000 feet, fewer species of small mammals were captured indicating that relative abundances were apparently lower than at lower elevations. Two species, the red-backed vole and the red squirrel, are reportedly limited to aspen and Douglas-fir stands similar to those found on Cathedral Bluffs.

More species of small mammals were captured in pinyon-juniper than in any other vegetation type, probably because of the greater habitat heterogeneity. Two species, the pinon mouse and Colorado chipmunk, were found only in the pinyon-juniper type. The bushy-tailed woodrat and golden-mantled ground squirrel also exhibited an affinity for this habitat.

The least chipmunk and deer mouse were the two most abundant species trapped, constituting over 80% of all small mammals captured in the study area.

Other species, including the thirteen-lined ground squirrel, long-tailed vole, montane vole and sagebrush vole, composed only a small proportion of the small mammals captured. The northern pocket gopher and porcupine are also residents of the Tract C-a area as are three lagomorph species; Nuttall's cottontail, the blacktailed jack-rabbit and the white-tailed jack-rabbit.

Three insectivores, the masked shrew, wandering shrew and Merriam's shrew (a first record for the Piceance Creek basin) have been identified to date (Finley 1975). Seven bat species: the hoary bat, big brown bat, silver-haired bat and four species of myotis have also been found in the study area.

The concepts of species diversity and total abundance were combined in an objective rating system to determine the relative importance of sampled habitats to small mammal populations. Habitats at lower elevations characterized by high shrub and/or tree cover -- e.g., bottomland sagebrush, pinyon-juniper/mixed brush, pinyon-juniper (south slope), pinyon-juniper (north slope), pinyon-juniper/sagebrush and rabbit brush -- supported greater diversities and abundances of small mammals than the other habitats investigated.

Relative abundance was determined to be the most important determination of species importance in the study area. Accordingly, the deer mouse and least chipmunk, accounting for 43.4 and 41% of the total trapped small mammal fauna respectively, were determined to be the most important small mammal species in the vicinity of Tract C-a. These species were found in every habitat and were the most abundant species in every habitat except Douglas fir and aspen (the red-backed vole is the predominant species in these habitat types). Since the least chipmunk and the deer mouse are both primarily seed-eaters, as are most of the small mammal species encountered in the study area, and both occupy the same ranges in the study area, the potential for inter-species competition is great. Competition appears to be avoided, however, by different activity periods -- the deer mouse is nocturnal while the least chipmunk is diurnal -- and by differential utilization of habitats. The deer mouse showed a greater affinity for habitats characterized by a high shrub cover and few trees while the least chipmunk was more closely associated with pinyon-juniper. The relative affinities of each small mammal species for each habitat, as defined by chi-square values, are presented in the Final Environmental Baseline Report (RBOSP 1977b).

C. Big Game - Big game species in the study area include mule deer and elk. Mule deer are the more important of the two in terms of numbers and recreational value. Relatively few elk are located in the study area and none were observed within the boundaries of Tract C-a during the baseline studies.

Mule deer use Tract C-a mainly as transitional and upper winter range. See Table 8-2-5 for estimated winter use by mule deer in the area. They begin moving into the area in October during their migration from higher elevations west of Tract C-a to winter range north and east of the tract. This movement is a gradual drift of the animals probably in response to temperature declines and increased snow depth in their higher-elevation summer range, and movements may vary from year to year. Mule deer may use Tract C-a throughout the winter but as snow levels increase, the largest concentrations of deer are located in the pinyon-juniper and sagebrush vegetation types northeast of the tract. During late April and early May, the largest herds of mule deer characteristically occur in the meadows and bottomlands east of the tract. Movement back to the summer range takes place over an extended period. The deer gradually drift to the higher elevations individually and in small groups. By late May, most of the deer are on their summer range.

The few mule deer remaining on the study area during the summer were scattered throughout the areas of higher elevation west of Tract C-a. The mixture of aspen, Douglas-fir, sagebrush and mixed brush vegetation types,

Table 8-2-5

ESTIMATED NUMBER OF MULE DEER PER SQUARE MILE BY BLOCK OF THE RBOSC STUDY AREA FOR TWO WINTER AND TWO SUMMER PERIODS (SEPTEMBER 1977 - SEPTEMBER 1979) 1/

| | Winter Period Days of Deer Use 2/ | | | | | | | | | | Summer Period 3/ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 120 | | 150 | | 180 | | 210 | | Average | | | |
| Block | 77-78 | 78-79 | 77-78 | 78-79 | 77-78 | 78-79 | 77-78 | 78-79 | 77-78 | 78-79 | 78 | 79 |
| 1 | 83.0 | 81.9 | 66.4 | 65.5 | 55.3 | 54.6 | 47.4 | 46.8 | 63.0 | 62.2 | 24.9 | 19.0 |
| 2 | 61.7 | 95.0 | 49.3 | 75.9 | 41.1 | 63.3 | 35.2 | 54.2 | 46.8 | 72.1 | 28.5 | 4.7 |
| 3 | 83.0 | 43.9 | 66.4 | 35.1 | 55.3 | 29.3 | 47.4 | 25.1 | 63.0 | 33.4 | 22.5 | 7.1 |
| 4 | 56.9 | 36.8 | 45.5 | 29.4 | 37.9 | 24.5 | 32.5 | 21.1 | 43.2 | 28.0 | 13.0 | 7.1 |
| 5 | 131.6 | 95.0 | 105.3 | 75.9 | 87.8 | 63.3 | 75.2 | 54.2 | 100.0 | 72.1 | 17.8 | 21.4 |
| 6 | 84.2 | 71.2 | 67.4 | 57.0 | 56.1 | 47.5 | 48.1 | 40.7 | 64.0 | 54.1 | 11.9 | 7.1 |
| 7 | 51.0 | 32.0 | 40.8 | 24.6 | 34.0 | 20.6 | 29.1 | 17.6 | 38.7 | 23.4 | 7.1 | 11.9 |
| 8 | 40.3 | 33.2 | 32.3 | 26.6 | 26.9 | 22.1 | 23.0 | 19.0 | 30.6 | 25.3 | 7.1 | 7.1 |
| 9 | 11.9 | 22.5 | 9.5 | 18.0 | 7.9 | 15.0 | 6.8 | 12.9 | 9.0 | 17.1 | 4.7 | 20.2 |
| Entire Study Area | 67.1 | 56.8 | 53.7 | 45.3 | 44.7 | 37.8 | 38.3 | 32.4 | 50.9 | 43.1 | 15.3 | 11.7 |

1/ Based on pellet group counts with a defecation rate of 13 pellet groups per deer per day.

2/ The exact number of days deer were in the study area is unknown; therefore, computations were made using various days of deer use.

3/ Based on 120 days in the summer accumulation varied.

combined with the range of slopes and aspects occurring west of Tract C-a, affords a variety of micro-habitats for mule deer. Eighty-five to 92% of the pellet groups counted during both summers of baseline study were located in the mixed brush vegetation type west of Tract C-a.

Tract C-a lies within CDOW Game Management Unit 22. This unit is classified by the CDOW as among the top 10 in the state for deer harvest. The contribution of Tract C-a habitats to this harvest cannot be estimated from available data, however, since hunting is not evenly distributed in the area. The hunting club located on tract is an indication that hunting is important in the area.

D. Predatory Mammals - The coyote, the long-tailed weasel and the short-tailed weasel are apparently the most common mammalian predators in the area, based on the results of observations to date. Coyote populations seem to be about average for the region based on a comparison of Tract C-a data with USFWS data within areas having similar habitat and physiographic characteristics (USDI 1973a, 1974). Other mammalian predators documented in the study area included the bobcat, badger and skunk. Although the mountain lion, black bear and ringtail have not been observed in the study area, they do occur in the region and may occasionally venture onto Tract C-a (Baker and McKean 1971).

E. Avifauna - During baseline studies, 139 avian species were observed in the study area. The following species are common year-round residents: common flicker, horned lark, Steller's jay, Scrub jay, pinon jay, blackbilled magpie, common raven, Clark's nut-cracker, black-capped chickadee, mountain chickadee, plain titmouse, red-breasted nuthatch and gray-headed junco. Based on annual averages, riparian habitats support the greatest bird density and diversity (RBOSP 1977b) while sagebrush and rabbitbrush habitats support the lowest numbers of species and individuals.

Avian abundance, diversity, and local distribution vary seasonally. During summer, the largest number of birds and the greatest species diversity were encountered in riparian, agricultural, Douglas-fir, aspen and pinyon-juniper vegetation types. The most common summer residents migrating into the area during June were the mountain bluebird, green-tailed towhee, chipping sparrow, Brewer's sparrow and vesper sparrow. During midwinter, sparseness of birds (low diversity and abundance) was exhibited. In spring and fall, a composite of winter and summer avifauna patterns occurred; many areas showed a typical winter pattern of uneven distribution, while other areas hosted many birds of several varieties (RBOSP 1977b).

Two species of upland game birds occur locally. A low to moderate population of sage grouse exists in upland sagebrush and mixed brush vegetation types in the southwestern portions of the study area. Sage grouse also occur on 84 Mesa. Blue grouse are year-round residents along Cathedral Bluffs. A low to moderate population of blue grouse inhabits mixed brush and aspen/mixed brush ecotonal areas during the breeding seasons, and inhabits dense stands of Douglas-fir and aspen in late fall and winter. The mourning dove is the most widely distributed and abundant (0.3 birds/ha) gamebird in the study area during the spring and fall. It resides in a variety of habitats, but it most often frequents pinyon-juniper and greasewood/sagebrush vegetation types.

In the Tract C-a vicinity, a few surface ponds and intermittent streams create isolated islands of habitat for waterfowl and shore birds. Fourteen species, primarily spring and fall migrants, have been recorded in the area. Of these, the mallard, green-winged teal, blue-winged teal and killdeer were the most common species.

Two migrant shorebird species, the greater sandhill crane and whooping crane, both of which are unusual to the study area, were observed during baseline studies. The population of greater sandhill cranes that nests in Colorado has been recognized as "endangered" by the CDOW. This designation does not apply to birds that stop in Colorado only during migration periods. The whooping crane is on the 1975 Federal endangered species list. The whooping crane that was sighted was probably an individual of the foster parent program of the U.S. Fish and Wildlife Service. These whooping cranes are raised from the egg by wild sandhill cranes and migrate with their adopted parents. They are sometimes observed in western Colorado during their migrations.

It is doubtful that the Colorado nesting population of sandhill cranes uses the RBOSC study area. However, the sighting of the mixed flock of greater sandhill cranes and one whooping crane in May 1976 indicates that these species occasionally stop at the study area during migrations. These stopovers are apparently linked to passage of storm fronts which force migrating birds away from their normal routes. This flock of cranes was probably utilizing Yellow Creek as a stopover enroute to Grays Lake National Wildlife Refuge.

Raptorial birds include the vultures, hawks, eagles, falcons and owls. Also included in this category, due to its similar ecological role, is the common raven (Craighead and Craighead 1969). Fourteen diurnal and four nocturnal raptors are known to use the Tract C-a area, based on observations during the baseline period. The red-tailed hawk was frequently observed throughout the year except during late winter. The rough-legged hawk was the most commonly observed wintering raptor. Golden eagles were observed throughout the year with the largest number observed during winter. The marsh hawk and American kestrel were commonly observed during summer, but only a few individuals were recorded during the winter. The common raven was the most prevalent raptor-like species observed in all vegetation types. Other diurnal raptors observed included the turkey vulture, goshawk, sharp-shinned hawk, Cooper's hawk, Swainson's hawk, bald eagle, prairie falcon, merlin and peregrine falcon. Nocturnal species observed included the great horned owl (most common), pygmy owl, short-eared owl and screech owl.

F. Reptiles and Amphibians - Six reptile species are known to occur in the study area, of which the sagebrush lizard is the most abundant and ubiquitous (percent relative abundance in all sampled areas = 47). The tree lizard, eastern fence lizard, shorthorned lizard (horned toad) and western terrestrial garter snake are less common (percent relative abundances = 42, 9, 1, and 1, respectively). The prairie rattlesnake also occurs. Habitats showing the highest abundance and diversity of reptiles were open, southfacing slopes with ledges and rock piles for basking and shelter, and with a few scattered bushes and deadfall for additional cover. The limited amount of this habitat in the study area results in a fairly low average reptile population density and diversity.

Three amphibian species: the chorus frog, Great Basin spadefoot and tiger salamander were documented as occurring in the study area at two ponds. The area has very few habitats suitable to breeding populations of amphibians, and abundance and species diversity is low where they do occur.

G. Invertebrates - Invertebrates were sampled in five of the most common vegetation types in the study area: bottomland sagebrush, north and south slope pinyon-juniper woodlands, upland sagebrush and mixed brush. A variety of sampling methods was used to identify the most abundant invertebrates within each vegetation type.

Major orders of ground dwelling invertebrates sampled in all vegetation types throughout the season were springtails (Collembola) and mites (Acari). Of the active flying insects, the numerically dominant taxa found in all vegetation types sampled belonged to two fly families, non-biting midges (Chironomidae) and anthomyiid flies (Anthomyiidae). Each shrub, tree and herbaceous vegetation type sampled had a complement of herbivore species, primarily from the order Homoptera. Ants (Formicidae) were the numerically dominant family found in all vegetative strata.

H. Feral Horses - Several bands of feral horses range over the study area. In contrast to the variable seasonal distribution of mule deer, feral horses remain in the study area throughout the year. In a January 1980 aerial census, 120 feral horses were counted in the study area. The BLM removed the majority of these horses in September 1980 and will attempt to keep the number in the study area to between 85 and 115 (Roberts 1980).

Feral horse herds ranged in all vegetation types and various bands were scattered over a large portion of the study area during the 2-year baseline study period. Most of the horses were seen in the area bounded by Big Duck Creek, Yellow Creek, Stakes Springs Draw (Left Fork), and the Cathedral Bluffs, although scattered individuals or small bands were occasionally observed outside this area. Long range movements of the various herds were probably limited by barbed wire fences.

During the summer, horses foraged in mixed brush, sagebrush, bottomland meadow and bald vegetation types. They loafed during mid-day near the same areas, often in an ecotone between two vegetation types or near large solitary trees. Many animals sought shade in pinyon-juniper stands during the hottest period of the summer day. Horses watered at springs or intermittent open water along Stake Springs Draw, Box Elder Gulch, Corral Gulch and Big Duck Creek. If gates were left open or fences were down, horses on 84 Mesa also watered at Yellow Creek or at stock tanks in Duck Creek. Horses were also observed loafing in the bottomlands near water sources in Spruce Gulch during summer periods.

I. Domestic Livestock - Cattle distribution in the area is determined by BLM grazing allotments. Cattle are moved to higher elevations in the spring as the snowpack recedes and vegetation becomes green. In the fall, inclement weather conditions force ranchers to move cattle to rangelands at lower elevations.

Three BLM grazing allotments have been set up in the vicinity of Tract C-a. Maps showing the size of these allotments are included in the RBOSP Terrestrial Annual Baseline Report (RBOSP 1976a). The grazing allotments have been placed under Allotment Management Plans (AMP) which provide the BLM with broad flexibility in establishing stocking rates, depending upon year-to-year range conditions. The allotments are as follows:

- Square S Allotment - Includes 28,328 ha (70001 A) of BLM lands and 4,730 ha (11,687 A) of patented lands for a total of 33,058 ha (81,688 A). The grazing season is May 1 through December 15. The BLM has estimated a carrying capacity of 4,390 animal unit months (AUM's), based on a 1941 Range Survey and a 1978 revised estimate. Carrying capacity has been recently increased by chaining of pinyon-juniper.
- Yellow Creek Allotment - Includes 29,334 ha (72,485 A) of BLM land and 1,692 ha (4,180 A) of patented lands for a total allotment of 31,026 ha (76,665 A). The grazing season is from April 15 through January 30. The BLM has estimated a carrying capacity of 3,618 AUM's, based on 1941 and 1973 range surveys and a 1978 revised estimate.

- Reagle Allotment - Includes 9,266 ha (22,898 A) of BLM lands and 987 ha (2,440 A) of patented lands for a total of 10,253 ha (25,338 A). The grazing season is May 1 to October 15. The BLM has estimated a carrying capacity of 1,616 AUM's based on a 1941 range survey and a 1978 revised estimate.

The northwest portion of Tract C-a is in the Yellow Creek Allotment and the remaining portion is in the Square S Allotment. Since cattle range freely on and off the tract within the allotments, actual stocking rates in AUM's have not been calculated for Tract C-a. The BLM estimates that the carrying capacity of Tract C-a is 500 AUM's (Roberts 1980).

J. Threatened and Endangered Species - Federal and State wildlife agencies and the Smithsonian Institution have compiled lists of plant and animal species which are "threatened", "rare", or "endangered". In determining the status of a species, the entire range of the species is considered. By Federal standards, an "endangered" species is in danger of extinction throughout all, or a significant portion, of its range; a "threatened" species is likely to become endangered within the foreseeable future throughout all, or a significant portion of its range; and a "rare" species exists as a small population with its range (USDI, 1973b).

Habitats of rare plants often occur on young or unstable geologic conditions such as talus slopes, mountain tops, rock cliffs or shale barrens. One formerly endangered plant species, the milkvetch, *Astragalus lutosus* (Smithsonian Institution, 1975), was found on shale outcroppings northwest of Tract C-a. The rare milkvetch is known to occur only on dry, calcareous shales at lower elevations in the drainages of the White River, Rio Blanco County, Colorado, and adjacent areas of Utah.

The peregrine falcon (*Falco peregrinus anatum*) is considered an endangered species by the USDI (1975). This falcon was observed four times in the Tract C-a study area during spring and summer 1975. Two of the observations were within the tract boundaries. The number of individuals the four sightings represent is unknown because of the high mobility of this raptor. It is unlikely that peregrine falcons nest in the study area because of the lack of large cliff faces and the paucity of water (Craig 1975).

The Colorado nesting population of the greater sandhill crane (<u>Grus canadensis tabida</u>) was considered endangered by the Colorado Wildlife Commission as of 1973. Approximately 30 greater sandhill cranes were observed in the study area during baseline studies. Based on observations made during spring and fall surveys of 1975, 84 Mesa and its environs may serve as migratory stopover areas for cranes during adverse weather conditions. Extensive surveys were conducted to determine if these cranes were nesting along the White River but none were sighted. In May 1976, one juvenile whooping crane was also observed in the area. A discussion of greater sandhill cranes and whooping cranes is included in the avifauna section of this chapter.

Bald eagles and the peregrine falcon were sighted occasionally as flyovers during baseline. Neither of these species has been seen near the tract during monitoring studies.

## 2.6 AQUATIC ECOLOGY

Aquatic habitat in the project area is primarily limited to ephemeral streams and small springs and seeps. The nearest fish populations are 20 miles to the north in the White River. A total of 35 stations was sampled during Aquatic Ecology Baseline Studies from October 1974 through September 1976 (Figure 8-2-8). The aquatic habitats sampled were divided into five types:

- Spring brook - Station 1-4, 6-13, 15-18
- Ponds - Stations 5, 14, 19
- Yellow Creek - Stations 20-22
- White River back channel - Stations 23, 27-29, 33
- White River open channel - Stations 24-26, 30-32, 34, 35

Stations 1-4 are located in small cool springs (rhenocrenes) with little macrophytic growth. Substrates at these stations are composed of loose aggregations of sand, gravel and shale pieces covered with periphyton. The other spring brook habitat type stations are similar to stations 1 through 4 and have substrates of gravel, sand and silt. The chemical characteristics of their waters are also similar to that of stations 1 through 4. However,

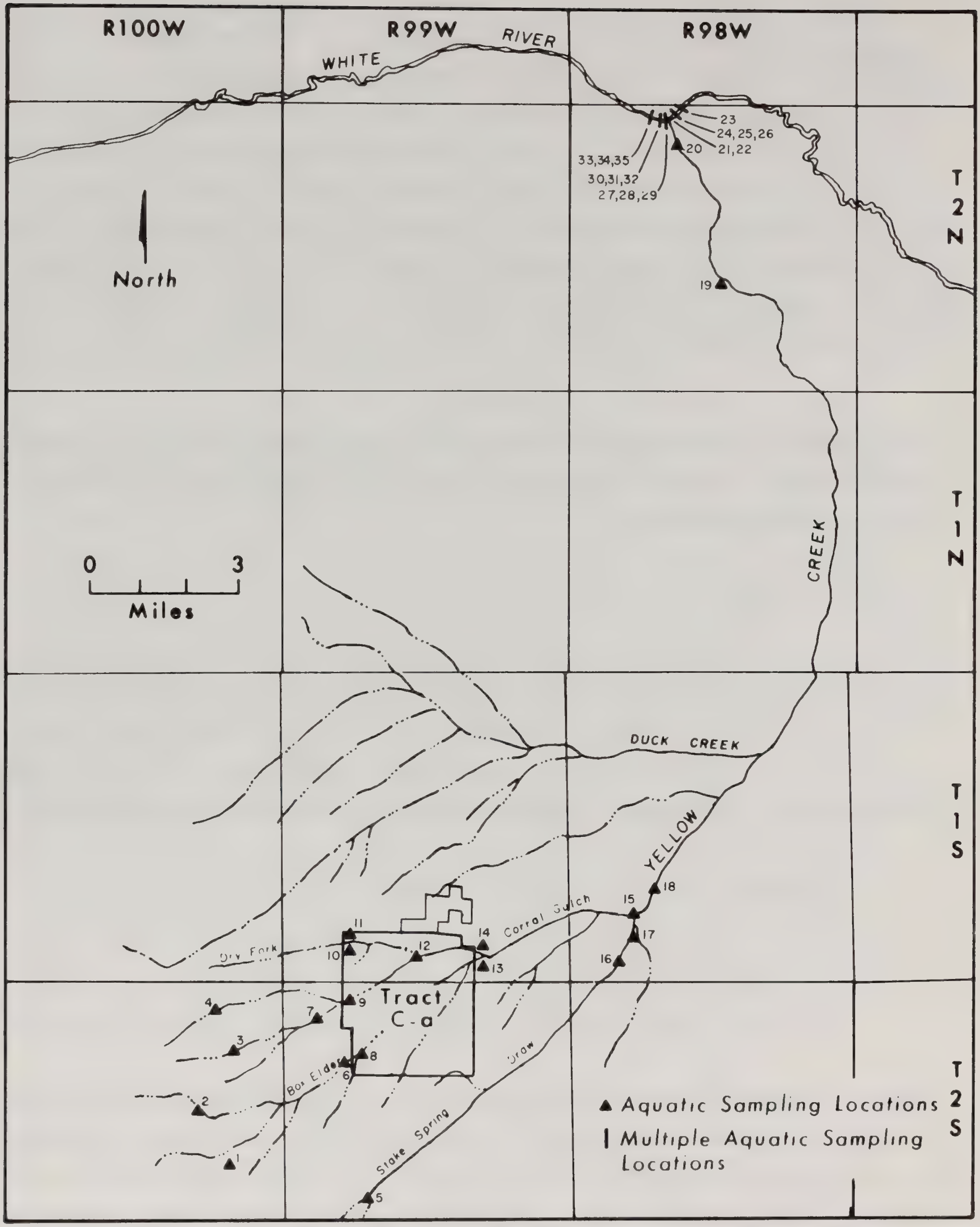



Figure 8-2-8
RBOSC Baseline Aquatic Sampling Locations

stations 10, 11, and 16 were dry throughout the baseline study period. These stations are located in large gulches which are wet only during local precipitation. Stations 7, 12, 15, 17 and 18 were dry during most of the sampling periods. Aquatic organisms were found at these stations when water was present, however. During the December sampling of 1974 some of the spring brook stations were frozen.

Stations 5, 14 and 19 were classified as ponds. Actually, Stations 5 and 19 are located directly downstream from heavily vegetated seepage areas which have many pond characteristics. Station 14 was a pond during 1974-1975, but the structure containing the pond washed out in early spring of 1976. As a result, station 14 was eventually almost filled with sand and silt. The species composition at Station 14 changed considerably as a result of this alteration.

Stations 20, 21 and 22 are very similar, being within 1000 m of each other along Yellow Creek near its confluence with the White River.

Stations 23, 27-29 and 33 were classified as back channel habitats. All of these stations are located in side channels of the White River where the water velocity is much lower than in the main river channel. The substrates in this habitat type are composed of cobble stones with rubble and gravel. Siltation is heavy during low flow periods of the year. Stations 24-26, 30-32 and 34 and 35 represent the open channel habitat type. These stations are found in the main channel of the White River.

Baseline studies were designed to inventory the aquatic biota of the study area and to determine the baseline characteristics of aquatic resources in the vicinity. Aquatic biota studies were conducted in conjunction with extensive surface water and ground water physicochemical studies. Species composition, relative abundance, and distribution of phytoplankton, zooplankton, macrophytes, periphyton, benthos and fish were determined. In addition, productivity studies were conducted for periphyton. Age and growth, condition and reproduction studies were conducted on fishes of the White River and lower Yellow Creek. Complete descriptions of the sampling methods which were employed appear in the RBOSP Annual Aquatic Baseline Report (RBOSP 1976b).

Species composition, diversity and relative abundance for each of the biotic groups was compared for each year of baseline studies and among habitat types. Some fluctuations were noted but, for the most part, these parameters remained stable throughout the study period.

Species composition of phytoplankton was generally similar among habitats (spring brook, pond, creek and river), but dominant taxa varied.

Rotifers were the most abundant zooplankton organisms, and were most numerous in the pond habitats. Protozoans were the second most abundant plankters but largest concentrations occurred in the river habitats. These variations reflect the importance of stream velocity to faunal distribution. Protozoan numbers increased with velocity while rotifer numbers declined. Rotifers tend to be destroyed by high turbulence and increased stream velocity.

Periphyton communities in the pond habitats were more diverse than those in the spring brook habitats, similar to those in creek habitats, and less diverse than those in the river habitats, as indicated by diversity indices. Mean organic weights per area of periphyton were also higher in the river habitats than in other areas.

Many benthic taxa were found in the White River and Yellow Creek drainages. Substrate characteristics appeared to be of major importance in determining species diversities. The number of taxa was lower in the creek habitats than at other stations. The heterogeneous substrate of the river habitats tended to increase benthic diversity. Physicochemical variations appear to influence benthic populations in the various habitat types. Many benthic organisms from the area reflected special adaptations for food gathering which have allowed them to survive within the somewhat adverse conditions of Yellow Creek and the White River.

Only 15 species of fish were collected throughout the 2-year baseline study. All specimens were taken from Lower Yellow Creek and the White River, near its confluence with Yellow Creek. More fish were recovered from the White River than from Yellow Creek. The speckled dace (Rhinicthes osculus) was the most abundant species collected. No threatened or endangered species were recovered from the study area. In general the distribution of fish catches was similar for both baseline study years. Spawning was earlier in 1976 than in 1975, which was apparently related to a shorter snow melt runoff period in 1976.

Baseline studies showed that phytoplankton, zooplankton and macrophytes occupy relatively unimportant roles in the aquatic ecosystem of the area. Periphyton are the major primary producers, and give rise to a significant portion of the free-floating planktonic organisms. Benthic organisms are the primary aquatic consumers on the tract in the absence of fish species. Fishes occur only in Yellow Creek and White River stations, as most on-tract surface water bodies are ephemeral. Macrophytes are limited to a few pond habitats.

## 2.7 CULTURAL RESOURCES

Artifacts recovered from Tract C-a and vicinity indicate there were at least four periods of occupation of the area; an Archaic period perhaps beginning as early as 9000 years before the Pleistocene; the Fremont Culture that began after 500 A.D.; the Ute Culture, whose beginnings are not presently established, but ended in 1880; and, finally, the 19th Century Anglos. The socio-political organization of early man (Archaic Period) in the area was probably uncomplicated. Exploitation was accomplished most efficiently by the extended family unit. These early inhabitants must have possessed considerable knowledge of natural history, seasonal game movements and ripening times of various edible plants, as these were the criteria that dictated their movements. Exploitation patterns indicate that deer, elk, plants, fish, insects, waterfowl, rodents and reptiles were eaten. Material culture was geared to frequent changes in location. Flexible containers of hide or basketry were used instead of ceramics. Other types of equipment were practical and portable. Clothing was minimal and housing was constructed only when a subsistence item was plentiful enough to support the group in one place for a period of time. Caves or overhangs were used when they occurred. Most Archaic artifacts found in the area were projectile points. The archaic occupation could have extended back several thousand years, but this cannot be positively confirmed from limited surface materials recovered during the survey. The discovery of a fragment possibly from a Paleo Indian projectile point could mean that man was utilizing the area at a much earlier date than previously expected.

As the Archaic pattern faded, it was replaced by the Fremont Culture. In general, this transition involved expansion of agricultural practices and use of pottery. Evidence for the project area, however, indicates that it is unlikely that agriculture was practiced in the immediate vicinity. Artifacts of the Fremont era are more refined that those from the Archaic period. Projectile points are smaller and shaped differently.

Introduction of the Ute culture (as indicated by presence of wickiups) into the area cannot be precisely dated. It may have occurred as an extension of the Fremont period characterized by increased use of horses and European goods.

The primary factor leading to the settlement of the study area by Euro-Americans appears to have been the cattle industry. There is no evidence that dry land farming was practiced, and there was no mining industry in the area prior to relatively recent oil shale development. Utilization of the area by Euro-Americans apparently falls into three periods:

- Period I - Initial Homesteading (ca. 1885 - 1895)
- Period II - Second Homesteading (ca. 1918 - 1930)
- Period III - Residual Exploitation (ca. 1950 - )

The first period is represented in the study area by three homestead sites, including 84 Ranch. Initial homesteading apparently resulted from man's attempt to utilize even marginal grazing lands for the production of cattle as land became increasingly scarce. These homesteads were apparently occupied for only a short while. Complete descriptions of these homesteads appear in the RBOSP Cultural Resource Survey Report (RBOSP 1976c).

Period II is represented by seven homestead sites and a school. This renewed homesteading period was probably generated by the passage of two new homestead acts - the "Enlarged Homestead Act of 1909" and the "Stock-Raising

Homestead Act of 1916". Both these acts enlarged the sizes of permissible homestead plots in an effort to satisfy western cattle interests. The sites indicative of this period have outbuildings and other improvements which suggest more permanent occupation than during initial homesteading. Use of 84 Ranch continued through this period, but the other Period I homesteads were abandoned before Period II began. Both Period II homesteads and 84 Ranch were apparently abandoned prior to 1950, probably during the Great Depression of the 1930's.

Period III was marked by intermittent use of the area by cattle ranchers living outside the study area. Previously abandoned homesteads were sometimes used as "cow camps", especially 84 Ranch. During this period wild horses were sometimes captured in horse traps constructed of pinyon-juniper limbs. Four of these horse traps remain in the area. Horse trapping probably continued until the passage of the Wild Horse and Burro Act of 1971 which made such activities illegal.

Paleo-finds were examined from 9 sites in the vicinity of Tract C-a. These finds included fossil fragments of a unintathere vertebra, a turtle carapace and a mammal from the Eocene period; fragments of petrified wood, (period not identifiable); and non-fossilized deer and bison bone. All of these finds are common in Eocene sediments of the entire Rocky Mountain area and as such do not represent significant Paleo-finds. These were found lying loose and could have been transported into the area by early man.

Two archaeological sites in the study area were designated as significant for eligibility to the National Register of Historic Places (see Section 7, Chapter 12 - Protection of Objects of Scientific and Historic Interest).

## CHAPTER 3
## AIR QUALITY IMPACT ASSESSMENT

The assessment of the air quality impacts is based upon air quality dispersion modeling, which was described in detail in Section 7, Chapter 5. The modeling results show that no National Ambient Air Quality Standard (NAAQS) or Colorado ambient standards will be exceeded due to air quality impacts from the Lurgi Demonstration Project. In addition, no applicable Prevention of Significant Deterioration (PSD) increments will be exceeded, either in the vicinity of the tract or at the nearest Federal Class I area, the Flat Tops Wilderness Area.

Since the NAAQS were established at levels that protect the public health and welfare, with an adequate margin of safety, it follows that no adverse impacts to public health or welfare will be caused by the Lurgi Demonstration Project. This conclusion is further reinforced because the more stringent PSD increments will not be exceeded, providing yet another level of assurance that no significant impacts will occur.

As discussed in Section 7, Chapter 5, air quality modeling has shown that visibility at the Flat Tops Wilderness will not be impacted by RBOSC activities at Tract C-a.

## CHAPTER 4
## ASSESSMENT OF IMPACTS ON TERRESTRIAL ECOLOGY

As is described in Chapter 1 of this section, the environmental impacts of the Lurgi Demonstration Project were assessed by modifying the outputs of the MIS assessment matrix to reflect the differences between the two projects. Measures to mitigate or avoid these potential impacts were subsequently developed, and net impacts were assessed.

A portion of the process summarized above involved an assessment of the impacts of the Lurgi Demonstration Project on terrestrial ecology. The results of that assessment are contained in this chapter, and include the following:

- Descriptions of the potential adverse impacts of the Lurgi Demonstration Project on terrestrial ecology
- Descriptions of the measures developed to mitigate or avoid the potential adverse impacts described
- Descriptions of the anticipated net adverse impacts of the Lurgi Demonstration Project on terrestrial ecology, considering mitigation/avoidance measures

Measures to mitigate or avoid potential adverse impacts on terrestrial ecology are not described in detail in this chapter. Instead, the various chapters in Section 7 which contain detailed descriptions of these measures are referenced.

Impacts are addressed in this Chapter, according to source, to indicate the relative impact of each aspect of the Lurgi Demonstration Project. Sources of impacts which were identified include construction, mining, operational, storage and transfer, disposal and secondary (manpower-related) activities. The specific potential impacts of each of these sources are addressed as one of five types: physical disturbance of habitat, physical damage to habitat, species exclusion from habitat, species disturbance and increased species mortality. Impacts are described as to specific nature, areal extent, duration, location, species affected and/or general severity.

Most of the five types of potential impacts listed above will be produced by more than one of the impact sources. In such instances, those aspects of the impact in question which are similar, regardless of the source of the impact, are not repeatedly discussed. For example, both construction and mining activities will result in physical disturbance of terrestrial habitat. The disturbance species and the manner in which they will be affected by such disturbance of similar habitat are essentially the same regardless of the source of disturbance. These aspects of physical disturbance of terrestrial habitat are, therefore, discussed in detail in relation to construction activities (Part 4.1 below), but only are briefly mentioned in relation to the potential impacts related to mining activities (Part 4.2 below), with references to the detailed discussion in Part 4.1. The extent, location and duration of mining-related physical disturbance of terrestrial habitat are fully discussed, however, as these aspects of the impact in question are quite different from the corresponding aspects of construction-related physical disturbance of terrestrial habitat.

Other activities in the vicinity have already caused limited habitat damage. Some habitats of the area show the effects of overbrowsing by deer and heavy grazing by livestock. The wildlife carrying capacity of these existing habitats can be greatly increased with proven range management techniques. The RBOSC Fish and Wildlife Management Plan (Section 7, Chapter 11) is designed to increase wildlife numbers in selected habitats somewhat removed from RBOSC activities. With this mitigation, wildlife numbers in Tract C-a and the surrounding area are not expected to be diminished by RBOSC activities.

## 4.1 CONSTRUCTION IMPACTS

A. Physical Disturbance of Habitat - The terrestrial habitat within the area required for roads and the various surface facilities of the Lurgi Demonstration Project will be disturbed during construction activities. Much of this disturbance will be temporary, however, as almost all of this terrestrial habitat will be reclaimed after project completion. (Some roads are expected to be maintained after project completion for public access.) Section 7, Chapter 8 (Land Rehabilitation and Erosion Control) describes the techniques and schedule which will be followed in reclaiming these habitats.

Table 8-4-1 summarizes the amount of terrestrial habitat which will be disturbed by construction of each of the project components listed. The locations of the project components listed in Table 8-4-1 are shown in Figure 8-2-1. A total of 97.7 ha (241.2 A) will be disturbed, 96.4 ha (238.1 A) of which will eventually be reclaimed (Table 8-4-1), resulting in a net loss of 1.3 ha (3.1 A).

Species which can be expected to be most affected by construction-related disturbance of terrestrial habitat include mule deer, avifauna, small mammals, feral horses and domestic livestock. The terrestrial habitat which will be disturbed is transitional winter range for mule deer (see Chapter 2, Part 2.5,C of this section). The estimated current population of mule deer in the vicinity of Tract C-a varies from 20 to 60 mule deer/square mile (8 to 23 mule deer/square kilometer). Thus, the initial construction-related disturbance of 97.7 ha (241.2 A) of terrestrial habitat has the potential to impact up to 22 mule deer.

This potential impact will be substantially mitigated by implementing the habitat enhancement program as discussed in the RBOSC Fish and Wildlife Management Plan.

The habitats to be disturbed support varying numbers of avifauna species during different seasons of the year. More birds are in the vicinity of the Lurgi Demonstration Project during the summer than winter. A total of 139 species were reported during baseline studies. The greatest impact will occur to those species which are dependent on pinyon-juniper habitat, because it will take more time to reclaim this habitat than others. Avifauna species common to brush habitat types will be impacted less than those species inhabiting other types. Reclamation and mitigation activities benefit some

Table 8-4-1

ESTIMATED ACREAGES OF TERRESTRIAL HABITAT DISTURBANCE AND RECLAMATION FOR THE LURGI DEMONSTRATION PROJECT

| Source of Disturbance | ACREAGE DISTURBED[1/] 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | Total |
|---|---|---|---|---|---|---|---|
| Construction Related Disturbance | | | | | | | |
| Haul Roads and Associated Disturbance | 44.1 | | | - | | | 44.1 |
| Access Roads and Associated Disturbance | 58.2 | | | - | | | 58.2 |
| Lurgi Plant Site | 45.9 | | | - | | | 45.9 |
| Miscellaneous Valley Bottom Disturbance | 12.2 | | | - | | | 12.2 |
| Shop and Office Facilities Area | 9.8 | | | - | | | 9.8 |
| Possible Expansion Adjacent to MIS Area[2/] | 71.0 | | | | | | 71.0 |
| Subtotals | 241.2 | | | - | | | 241.2 |
| Mining Related Disturbance | | | | | | | |
| Phase One Pit | 26.7 | | | - | | | 26.7 |
| Phase Two Pit | | | | 16.4 | | | 16.4 |
| Subtotals | 26.7 | | | 16.4 | | | 43.1 |
| Storage and Transfer Related Disturbance | | | | | | | |
| Settling Ponds | 31.3 | | | 3.5 | | | 34.8 |
| Topsoil Stockpiles | 50.7 | | | 15.8 | | | 66.5 |
| Overburden Stockpiles | 33.8 | | | 57.8 | | | 91.6 |
| Explosives Storage Area | 0.3 | | | - | | | 0.3 |
| Feed Shale Stockpiles | 37.3 | | | - | | | 37.3 |
| Pit Dewatering Treatment Ponds | 7.2 | | | - | | | 7.2 |
| Lurgi Water Storage Ponds (Bio-treatment and High TDS) | 19.3 | | | - | | | 19.3 |
| Utility Corridors | 39.0 | | | 9.4 | | | 48.4 |
| Subtotals | 218.9 | | | 86.5 | | | 305.4 |
| Disposal Related Disturbance | | | | | | | |
| Phase I Processed Shale Disposal Area | 88.0 | | | - | | | 88.0 |
| Phase II Processed Shale Disposal Area | - | | | 99.8 | | | 99.8 |
| Subtotals | 88.0 | | | 99.8 | | | 187.8 |
| Totals | 574.8 | | | 202.7 | | | 777.5 |

Table 8-4-1 (Cont'd)

ESTIMATED ACREAGES OF TERRESTRIAL HABITAT DISTURBANCE
AND RECLAMATION FOR THE LURGI DEMONSTRATION PROJECT

| Source of Disturbance | ACREAGE RECLAIMED[1/] 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | Total |
|---|---|---|---|---|---|---|---|---|
| Construction Related Disturbance | | | | | | | | |
| Haul Roads and Associated Disturbance | | 8.6 | | | | | 35.5 | 44.1 |
| Access Roads and Associated Disturbance[3/] | | 12.9 | | | | | 42.2 | 55.1 |
| Lurgi Plant Site | | | | | | | 45.9 | 45.9 |
| Miscellaneous Valley Bottom Disturbance | | | | | | | 12.2 | 12.2 |
| Shop and Office Facilities Area | | | | | | | 9.8 | 9.8 |
| Possible Expansion Adjacent to MIS Area[2/] | | | | | | | 71.0 | 71.0 |
| Subtotals | | 21.5 | | | | | 216.6 | 238.1 |
| Mining Related Disturbance | | | | | | | | |
| Phase One Pit | | | | | | | 26.7 | 26.7 |
| Phase Two Pit | | | | | | | 16.4 | 16.4 |
| Subtotals | | | | | | | 43.1 | 43.1 |
| Storage and Transfer Related Disturbance | | | | | | | | |
| Settling Ponds | | | | | | | 34.8 | 34.8 |
| Topsoil Stockpiles | | | 12.3 | | | | 54.2 | 66.5 |
| Overburden Stockpiles | | | | | | | 91.6 | 91.6 |
| Explosives Storage Area | | | | | | | 0.3 | 0.3 |
| Feed Shale Stockpiles | | | | | | | 37.3 | 37.3 |
| Pit Dewatering Treatment Ponds | | | | | | | 7.2 | 7.2 |
| Lurgi Water Storage Ponds | | | | | | | 19.3 | 19.3 |
| Utility Corridors | | 39.0 | | 9.4 | | | | 48.4 |
| Subtotals | | 39.0 | 12.3 | 9.4 | | | 244.7 | 305.4 |
| Disposal Related Disturbance | | | | | | | | |
| Phase I Processed Shale Disposal Area | | 11.0 | | | | | 77.0 | 88.0 |
| Phase II Processed Shale Disposal Area | | | | | | | 99.8 | 99.8 |
| Subtotals | | 11.0 | | | | | 176.8 | 187.8 |
| Totals | | 71.5 | 12.3 | 9.4 | | | 681.2 | 774.4 |

1/ All acreages include a buffer zone, all of which may not be disturbed.
2/ Acreage for on-tract construction camp which is being considered.
3/ Some access roads will be retained for public access, and will not be reclaimed.

species more than others. Impacts to avifauna will be small due to the limited amount of avifauna habitat to be disturbed.

Small mammals habitat in the construction areas will be disturbed, but permanent habitat loss will be only 1.3 ha (3.1 A). Permanent adverse impacts to small mammal populations in the Lurgi Demonstration Project area are expected to be small. The habitat enhancement techniques discussed in the Fish and Wildlife Management Plan which are designed to increase deer carrying capacity will also benefit small mammals. In addition, reclamation of habitats disturbed during construction will provide an extra food source for small mammals.

The impact on feral horses from construction-related habitat disturbance is not expected to be important. The BLM currently controls the area herd at levels well below the carrying capacity of the area. In addition, the habitats to be affected by construction are not heavily used by feral horses (see Chapter 2, Part 2.5,H of this section).

The terrestrial habitats which will be disturbed by construction activities represent approximately 28 animal unit-months (AUM's) of livestock grazing potential, according to the most recent BLM estimates. Less than 1 AUM will be permanently lost. This impact is insignificant compared to the BLM estimate of 500 AUM's for Tract C-a (Roberts 1980).

B. Physical Damage to Habitat - The vegetative productivity of terrestrial habitats adjacent to construction sites may be decreased somewhat due to fugitive dust emissions associated with construction activities. These emissions will be controlled by application of water and/or other dust suppressants during construction activities (see Section 7, Chapter 5 for estimates of construction - related fugitive dust emissions and a description of anticipated controls). The source of impact will cease after construction is completed, and no permanent, adverse vegetative impacts are anticipated.

The surface disturbance associated with construction activities may also result in localized increases in erosion and sediment transport. Prompt stabilization techniques such as hydromulching, together with timely revegetation (as described in Section 7, Chapter 8), will effectively mitigate this potential impact.

C. Species Disturbance - The breeding success of avifauna species in the immediate vicinity of construction sites may be adversely affected by the noise levels and physical disturbances resulting from construction activities. This potential impact (and many others) will be mitigated by general policies of minimizing noise levels associated with all phases of the Lurgi Demonstration Project and holding vehicular traffic to a minimum.

## 4.2 MINING IMPACTS

### A. Open Pit Development Impacts

1. Physical Disturbance Of Habitat - A total of 17.4 ha (43.1 A) of terrestrial habitat will be disturbed during development of the open pit mine. A total of 10.8 ha (26.7 A) will be disturbed in 1981 during Phase I of open pit development, and 6.6 ha (16.4 A) will be disturbed in 1984 during Phase II of open pit development. Table 8-4-1 summarizes the amount of terrestrial habitat which will be disturbed as a result of mining activities. The habitat loss and other impacts associated with stockpiling of topsoil, overburden and feed shale are discussed in connection with the impacts of storage and transfer activities. Figure 8-2-1 illustrates the proposed open pit location. With the exception of the pit highwalls, all of the terrestrial habitat disturbed during open pit development will be reclaimed, as described in Section 7, Chapter 8 and Table 8-4-1.

The same terrestrial species will be affected by terrestrial habitat disturbance associated with open pit development as will be affected by construction-related habitat disturbance, and include mule deer, feral horses, avifauna and small mammals. Transitional mule deer winter range and feral horse habitat will be temporarily lost. Approximately 5 AUM's of livestock grazing potential will be temporarily removed from production, and small mammals inhabiting the development area will be destroyed. Similarly, the programs and procedures to mitigate the potential adverse impacts of terrestrial habitat disturbance by construction-related activities are applicable to potential impacts associated with habitat disturbance resulting from open pit mine development. The programs described in RBOSC's Reclamation and Fish and Wildlife Management plans will effectively mitigate the potential adverse impacts of terrestrial habitat disturbance resulting from open pit mine development. Potential adverse impacts will be effectively mitigated by a combination of habitat restoration and habitat enhancement, as has been discussed.

2. Physical Damage to Habitat - The vegetative productivity of terrestrial habitats adjacent to open pit mine development sites may be slightly decreased due to fugitive dust emissions associated with open pit development. This impact will consist of the dust emissions produced by blasting activities and overburden removal (see Section 7, Chapter 5 for estimates of fugitive dust emissions and anticipated emission controls). The potential for fugitive dust emissions associated with overburden removal is much greater than for emissions associated with blasting. Overburden removal will involve a much greater disturbance than blasting, and will occur more continuously than blasting. No permanent adverse impacts are expected to result from these emissions. The potential terrestrial habitat damage associated with storage and transfer of topsoil, overburden and feed shale produced during open pit development is assessed in Part 4.4 of this chapter.

3. Species Disturbance - Terrestrial species in the vicinity of the open pit development site may be slightly affected by blasting noise. This impact is expected to be insignificant.

B. Dewatering Impacts

1. Physical Damage to Habitat - The dewatering/reinjection program is expected to have some effect on the surface flow of springs and seeps in the area near the open pit area and downgradient from the reinjection wells. These impacts are described in the assessment of potential hydrology impacts (Chapter 6 of this section). The amount of riparian vegetation will decrease in areas where surface flow is diminished, but will increase in areas where surface flow is augmented by reinjection. The overall impacts are thus

expected to be minimal. Following termination of the dewatering/reinjection program, these impacts can be expected to gradually diminish as the hydrologic system reverts to predevelopment conditions.

The surface flow changes which have been described can also be expected to influence the distribution of the terrestrial fauna in the Lurgi Demonstration Project area. If it proves necessary, programs will be implemented to increase surface water availability in areas adjacent to the Lurgi Demonstration Project to mitigate any impacts. Such programs will be designed to increase carrying capacity in these areas. No significant adverse impacts to terrestrial fauna are expected to result from dewatering activities.

## 4.3 OPERATIONAL IMPACTS

A. Physical Damage to Habitat - Lurgi Demonstration Project operations are expected to produce both airborne emissions and aqueous effluents. The impacts of these discharges on the air and water quality of the Lurgi Demonstration Project area are assessed in Chapters 3 and 6 of this section, respectively. Due to the control measures which will be applied to the sources of these emissions, impacts to air and/or water quality are not expected to result in any significant damage to terrestrial habitat.

B. Species Exclusion from Habitat - Portions of the Lurgi Demonstration Project operations will be fenced for reasons related to safety and security. The areas to be fenced will include the processed shale disposal area and holding and evaporation ponds.

Terrestrial species which will be excluded from fenced areas include feral horses and livestock. Fenced areas will be functionally destroyed as habitat for these species; the carrying capacity for these species of the fenced areas will be lost for the duration of the project.

C. Species Disturbance - Several aspects of Lurgi Demonstration Project operations (e.g. crushing, retorting) are expected to produce significant noise levels. These noise levels will be controlled as described in Section 7, Chapter 4. The controlled noise levels produced may adversely impact the breeding success of terrestrial species in the vicinity of the processing area, and may also result in diminished numbers of animals in the vicinity of the processing area.

## 4.4 STORAGE AND TRANSFER IMPACTS

A. Physical Disturbance of Habitat - Table 8-4-1 summarizes the amount of terrestrial habitat that will be disturbed by Lurgi Demonstration Project storage and transfer facilities. A total of 123.6 ha (305.4 A) of terrestrial habitat will be disturbed. All of this habitat will eventually be reclaimed, as described in Section 7, Chapter 8 and Table 8-4-1. Figure 8-2-1 illustrates the locations of each of the facilities listed in Table 8-4-1. Storage and transfer facilities include topsoil, overburden and feed shale stockpiles; water storage ponds; product oil storage facilities; conveyors; and utility corridors.

The terrestrial fauna which are most likely to be affected by such disturbance of terrestrial habitat have been identified elsewhere in this chapter. The anticipated effects on these species have also been discussed, as have the measures developed to mitigate or avoid these effects (see Part 4.1, A above).

B. Physical Damage to Habitat - Transfer of topsoil, overburden and feed shale from the open pit to various stockpiles will produce fugitive dust emissions. The stockpiles themselves may produce fugitive dust emissions when subjected to high winds. Conveying feed shale from the stockpile to the crushing facilities and conveying processed shale from the processing area to the processed shale disposal area are additional potential sources of fugitive dust (see Section 7, Chapter 5 for estimates of transfer and storage-related fugitive dust emissions and for descriptions of anticipated fugitive dust controls). These fugitive dust emissions are not expected to result in any significant adverse impacts on terrestrial habitats, however, due to the mitigating effect of anticipated fugitive dust controls.

Exhaust emissions from gasoline and diesel equipment have the potential to adversely impact terrestrial habitats adjacent to transfer areas, but these impacts will be minimized by standard emissions controls on all such equipment.

Storage and transfer of fuels, chemicals, explosives, machinery, project wastes and product oil may result in accidental spills which could adversely impact the terrestrial ecology of the Lurgi Demonstration Project area. The nature of such potential adverse impacts cannot be specified, as this would be dependent on the nature of the spilled substance, and the location of the spill.

RBOSC has developed a Spill Contingency and Hazardous Waste Management Plan (Section 7, Chapter 7). This plan describes the procedures which will be implemented to prevent such spills. Successful implementation of this control plan will minimize the potential adverse impacts to terrestrial ecology caused by such a spill.

C. Species Disturbance - Transfer of topsoil, overburden and feed shale from the open pit mine to various stockpiles will be accomplished by truck hauling. This activity will produce noise levels which may adversely affect avifauna breeding success, as discussed in Part 4.1, C above.

4.5 DISPOSAL IMPACTS

A. Physical Disturbance of Habitat - A total of 76.0 ha (187.8 A) of terrestrial habitat will be disturbed between 1981 and 1984, in developing the processed shale disposal area for the Lurgi Demonstration Project (see Section 5, Chapter 2). The location of the processed shale disposal area is shown in Figure 8-2-1. The entire area will eventually be reclaimed, as described in Section 7, Chapter 8.

The terrestrial fauna which are most likely to be affected by such disturbance of terrestrial habitat are the same as those identified previously. The anticipated effects of such habitat disturbance on these species have also been discussed, as have the measures developed to mitigate or avoid these effects (see Part 4.1, A above).

B. Physical Damage to Habitat - Fugitive dust emissions from the processed shale disposal area could slightly decrease the vegetative productivity of terrestrial habitats adjacent to the disposal area (see Section 7, Chapter 5 for estimates of fugitive dust emissions from the processed shale area and for a description of fugitive dust control measures). The fugitive dust control measures that will be applied to the processed shale disposal area are expected to effectively mitigate this potential adverse impact on terrestrial habitat.

Leachate or runoff from the processed shale disposal may have the potential to adversely affect adjacent terrestrial habitats. The extent of this hazard will be evaluated during a testing program to be conducted during Phase I of the Lurgi Demonstration Project (see Section 5).

## 4.6 SECONDARY IMPACTS

Secondary impacts include the effects on terrestrial ecology due to increased human activity associated with development and operation of the Lurgi Demonstration Project.

A. Physical Disturbance of Habitat - The development and operation of the Lurgi Demonstration Project is expected to require a work force totaling less than 550. A portion of this work force will reside in Rifle and Meeker. The added demands which these people place on their communities will contribute to the growth-related disturbance of terrestrial habitat in these communities.

B. Physical Damage to Habitat - New road systems and increased numbers of employees are likely to result in increased recreational use of Tract C-a and the general vicinity. Accompanying increases in off-road vehicle use may adversely affect vegetation in these areas. RBOSC has developed a brochure for employees and visitors which outlines the potential adverse impacts on vegetation of off-road vehicle use (see Section 7, Chapter 11), in an effort to discourage this practice.

C. Species Disturbance - The presence of and daily commuting activities of up to 550 people will result in additional disturbance to local wildlife. The extent of the disturbance will be largely dependent on the behavior of the individuals involved. RBOSC has developed a program for control of such human disturbance of wildlife as part of the RBOSC Fish and Wildlife Management Plan. Successful execution of this program is expected to partially mitigate the potential adverse impacts on local wildlife of increased human activity.

D. Increased Mortality - New road systems and increased employment are likely to result in an increase in hunting pressure (both legal and illegal) and wildlife-vehicle collisions in the vicinity of Tract C-a. Increased wildlife mortality is expected to occur as a result. Mule deer are expected to be the species most significantly affected. These potential adverse impacts on wildlife will be partially mitigated by successful implementation of RBOSC's program for control of human disturbance of wildlife.

# CHAPTER 5
# ASSESSMENT OF AQUATIC ECOLOGY IMPACTS

Streams and creeks on and near Tract C-a have limited flow; most are either intermittent or ephemeral. As a result, fish occur only in lower Yellow Creek and the White River. Since there is no continuous flow from the project area to lower Yellow Creek or the White River, no significant impacts to fish are anticipated as a result of project development.

Baseline data indicate that periphyton are the major primary producers in the project area and benthic invertebrates the primary aquatic consumers. Thus, the assessment of aquatic impacts will concentrate on the effects of project development on the periphyton and benthic invertebrate populations.

## 5.1 CONSTRUCTION IMPACTS

Construction activities will increase sedimentation to the streams. Deposition of this sediment on the stream bottom can fill the interstitial spaces between rocks and reduce the habitat of benthic invertebrates. Accumulation of sediments may result in a shift in the composition of the benthic invertebrate population toward greater percentages of Oligochaetes (segmented worms) and Chironomids (midges) which prefer silt laden substrates, and away from organisms such as caddisflies and mayflies which are generally less tolerant of siltation effects. Increased siltation and turbidity will also favor benthic invertebrates that are adaptively protected, such as Caenis spp. and Tricorythodes spp.

Suspended sediments also cause increased turbidity, which in turn inhibits light penetration and thereby reduces primary productivity in the stream. Sediment accumulation in pools may bury some of the immobile periphyton species. Increased silting will favor algal taxa which are adapted to a depositing environment, especially the mobile pennate diatoms. These changes in the periphyton and benthos communities will be limited to areas on or near the tract. Siltation and increased turbidity are not likely to affect the biota or water quality of the White River since there is no continuous flow from Tract C-a through Yellow Creek to the White River. The increase in erosion and siltation will be minimized through the implementation of the Land Rehabilitation and Erosion Control Plan (Section 7, Chapter 8).

Activities such as diversion of flow and road encroachment will alter the aquatic habitat in some locations. This may result in a temporary decline in the populations of periphyton and benthic invertebrates in the areas affected. Road encroachment and other streamside disturbances will destroy some of the riparian vegetation which provides cover and shade, stabilizes banks and provides detrital input that is a key element of the aquatic food web. These impacts will be minimized by regulating the amount of disturbance in and along the existing stream channels.

## 5.2 MINING IMPACTS

The primary effects of mining on aquatic habitats will be a reduction in flow in certain aquatic habitats on and near Tract C-a due to mine dewatering. The impacts of dewatering will be mitigated by reinjecting a portion of the water produced by mine dewatering operations. Reinjection may cause a change in the distribution and volume of surface flow in the region.

The dewatering process may convert some of the streams in the region from permanent to intermittent flow. Comparison during the baseline period (RBOSP 1977b) of the aquatic communities in intermittent and permanent streams show that there was no major difference in the composition of the periphyton communities. Decreases in flow are not likely to greatly affect periphyton community composition. Although densities of benthic invertebrates were lower at the intermittent stream stations than at stations on streams with permanent flow, the benthos of the region is also well adapted to the intermittent conditions. Short life cycles with resistant stages in the life cycle enable many benthic invertebrates to withstand droughts. However, the length and frequency of the dry periods will determine which of the species will survive. Since there is no evident surface flow connecting Tract C-a with lower Yellow Creek, the fauna of lower Yellow Creek or the White River do not depend upon biotic input from streams in the project area. Thus, there should be little or no effect on the biota of lower Yellow Creek or the White River resulting from changes in the benthos and periphyton communities in the vicinity of Tract C-a.

In the event that the reinjection system is shut down, a maximum of 2,000,000 gpd may be discharged into Corral Gulch. Such a discharge may cause occasional erosion of streambanks and scouring of the stream bottom near the points of discharge. Periphyton and benthic invertebrate populations may be reduced in the vicinity immediately downstream from these discharges due to the wide fluctuation in flow.

## 5.3 PROCESS IMPACTS

At full operating capacity, approximately 600,000 gallons of water per day will be required to meet the requirements of the Lurgi demonstration plant, processed shale disposal, and support facilities. This volume of flow will be supplied mainly by water produced during mining operations. At times, this water will be totally consumed by the water requirements of the retorting process and for processed shale moisturization. When additional water is not needed for processed shale moisturizing, a maximum of approximately 110,000 gpd may be discharged into Corral Gulch. This discharge is not expected to result in any significant impacts to either the stream channel or benthos and periphyton communities of Corral Gulch.

Studies of the effects of leachate from processed shale on aquatic organisms have indicated that leachate from certain processed shales contains concentrations of certain trace metals that may be toxic to some aquatic organisms (Skogerboe et al 1979). As a precautionary measure and for testing purposes for the Lurgi Demonstration Project, RBOSC is designing a processed shale disposal facility (See Section 5, Chapter 2) that will contain all leachate from the processed shale. Thus, no adverse effects to aquatic organisms should result from the processed shale disposal operations.

Sanitary wastes from the mining and processing operations will be treated prior to discharge into Corral Gulch. This treated effluent may still contain nutrients that stimulate the growth of periphyton and other aquatic vegetation. Effects would be greatest during low flow periods when the treated effluent would constituent a large proportion of the total flow in Corral Gulch. Some nuisance growth of aquatic plants may occur immediately downstream from the discharge points during low flow periods of late summer and early fall.

Accidental spills or seepage of oil, gas, diesel fuel, ammonia nitrate, etc. could adversely affect aquatic organisms. The severity of the impact depends on the spilled substance, location and time of the release. Large spills would rapidly move through the stream during high flow periods and would affect nearly all stream inhabitants. Small spills or continuous low-level leaks would only affect immobile species in the immediate vicinity of the source of contamination.

Due to the distances and lack of continuous surface flow from the project area to the White River, it is unlikely that a project-related spill or seepage of material would ever affect the aquatic biota of the White River. A detailed discussion of the plans for preventing and controlling spills or leakage of potentially hazardous or toxic materials is included in Section 7, Chapter 7.

# ASSESSMENT OF POTENTIAL HYDROLOGIC IMPACTS

The construction and operation of the Lurgi Demonstration Project facility and the associated existing MIS facility will potentially alter the natural hydrologic system. The implementation of each of the systems defined in the proposed water management plan (Section 7, Chapter 6) will impact the existing hydrologic balance. These impacts include alterations in the quality, quantity and regimen of surface and sub-surface water flow. Direction of the ground water flow, flow rates, flood routing, peak flows and water quality may be affected. In most cases these impacts will not be adverse or will be insignificant. In some cases the potential for significant adverse impacts may exist and various mitigative measures must be taken to minimize impacts.

## 6.1 INTRODUCTION AND SUMMARY

The operation of the Lurgi Demonstration Project and the associated MIS facility will require the use and consumption of water from the natural system. Water consumption will occur as evaporative losses from the Lurgi process, evaporation of poor quality water to prevent adverse impact that might result from discharge, evaporation from water storage areas or as water used for reclamation and dust control. Such losses cannot be prevented and are necessary for operation of the project. The project is designed, however, to minimize these water losses without seriously degrading water quality. This has been accomplished by planning operations on as small a water demand as is feasible, and by recirculating waste streams generated by the project. Small waste streams generated by sanitary facilities at the mines are the only such streams that may not be recirculated.

The water necessary to meet the operational demands will be drawn from the Upper Aquifer where acceptable water is available for use in the required quantities. Additional water will also be withdrawn from the Upper Aquifer to allow mining in the dry at the open pit. This removal will expand the cone of depression created by MIS dewatering in the aquifer around the removal area. Some of the water removed from the mine will be injected back into the Upper Aquifer at strategic locations in the tract vicinity to control the spread of the cone of depression into areas where it would be expected to create significant adverse hydrologic impacts.

The volume of water flowing through the surface water system will increase with the initiation of the Lurgi Demonstration Project for two reasons. First, various areas over the site will be disturbed, reducing infiltration rates and increasing runoff rates for a given precipitation event. Second, for a variety of reasons it may be occasionally necessary to discharge some of the removed ground water, possibly after some other use, to the natural streams. In addition, because flow paths and times of concentrations in the system will be altered, the routing of such water through the streams should differ from natural conditions.

To prevent adverse effects from increased streamflow and altered flood routing, a series of holding and settling ponds will be constructed at strategic locations in the surface hydrologic system. Water will be routed through these ponds to reduce the sediment load, and the discharge controlled so that natural peak flows in the streams will not be exceeded. This will create additional periods of streamflow that would not occur under the natural system. Such flow should not adversely impact the hydrologic system, and probably will be beneficial.

When necessary, diversion channels will be used to carry natural streams around disturbed areas. These channels will be designed to carry at least the flow from a storm of 24-hour duration and a 10-year recurrence interval. This channel design reduces the potential for flood damage.

The operation of the Lurgi Demonstration Project will generate several streams with degraded water quality. This water will include process waste streams and runoff from disturbed areas, ore stockpiles and processed shale. Any such water which can be utilized in the project operation will be salvaged, thus reducing the overall water required from the natural system. Inasmuch as the quality of the runoff from ore stockpiles and processed shale is uncertain, the project has been designed to collect such water to prevent adverse impacts which might occur if the water were released to the natural system. If monitoring of this water indicates it is of suitable quality, the water will be utilized in process operations; otherwise it will be evaporated. Sediment-laden water from disturbed areas will be routed through a pond to remove suspended sediment prior to discharge into the natural streams. The process waste streams will be utilized or treated and discharged.

The Lurgi Demonstration Project operation has been designed to minimize the impacts on the natural hydrologic system. The impacts that do occur will be highly localized, should have no significant adverse effect, and in some cases may be beneficial. On completion of the operation, including reclamation, the site will naturally return to the pre-existing hydrologic balance.

## 6.2 WATER SUPPLY WELL, SURFACE MINE AND MIS SYSTEMS - POTENTIAL IMPACTS AND MITIGATIVE MEASURES

A. Dewatering - Potential Impacts - The excavation of the surface mine will penetrate both water-bearing zones of the Upper Aquifer, producing flow to the mine. The existing MIS underground mine has penetrated these zones and is presently receiving flow from the aquifer. For the efficient operation of both mines, such water must be removed. During the Lurgi Demonstration Project operation, water may also be removed from wells near the surface mine for water supply purposes. Drawdown, created by dewatering, could impact the natural hydrologic system in two ways.

1. Reduction of Aquifer Discharge - Lowering piezometric levels could reduce or eliminate aquifer discharge at springs and other points reducing water available in the surface system.

2. Alteration of Ground Water Flow Directions - The cone of ground water depression will alter the direction of ground water flow. Under natural conditions, ground water in the Upper Aquifer flows west to east across the tract, with a slight northerly trend. When dewatering occurs, and a cone of depression develops, ground water will flow toward the dewatering area.

B. Dewatering - Mitigative Measures - The lowering of the Upper Aquifer piezometric levels will not necessarily create significant adverse impacts to the natural hydrologic system. Although the cone of depression locally alters directions of ground water flow, such alterations will be limited to an area around the tract. Regionally, ground water flow directions will not change. Therefore major adverse hydrologic impacts from dewatering would occur only if piezometric levels were lowered enough to reduce or eliminate spring flows resulting from Upper Aquifer discharge.

Figure 8-6-1 is taken from Piceance Basin Spring Hydraulics Investigation (1978) prepared by the Office of the State Engineer, Division of Water Resources, State of Colorado. This figure indicates regions where Upper Aquifer piezometric levels are higher than the ground surface elevations. The report states that springs in those areas are probably Upper Aquifer discharge points, while springs outside of those areas are probably discharge points from perched aquifers which will not be affected by Upper Aquifer dewatering. As the figure illustrates, the Upper Aquifer piezometric levels are higher than the ground surface to the east and south of the tract. Based on this study it is expected that any reduction in spring flows resulting from dewatering would occur in these areas. To prevent the cone of depression from affecting these areas, RBOSC operates and will continue to operate a system of injection wells east and south of the dewatering areas which returns excess water back to the Upper Aquifer.

There is some evidence that while Upper Aquifer water is stored on the surface, the water becomes more chemically oxidizing (increased Eh). When this water is injected, it may create locally more oxidizing conditions in the Upper Aquifer. Should this occur, the increase in Eh might be reflected in the aquifers' water chemistry by increased dissolved solids, increased sulfate, increased iron and selected trace metals and decreased sulfides. The available water chemistry data for the dewatering-injection cycles of the existing MIS operations do not reflect any of these changes since injection began. This may indicate no change in redox conditions or may indicate that redox conditions have changed, creating subsequent small changes in selected constituents that are within the range of the existing data and therefore undetectable. In either case, the available data indicate that the impacts

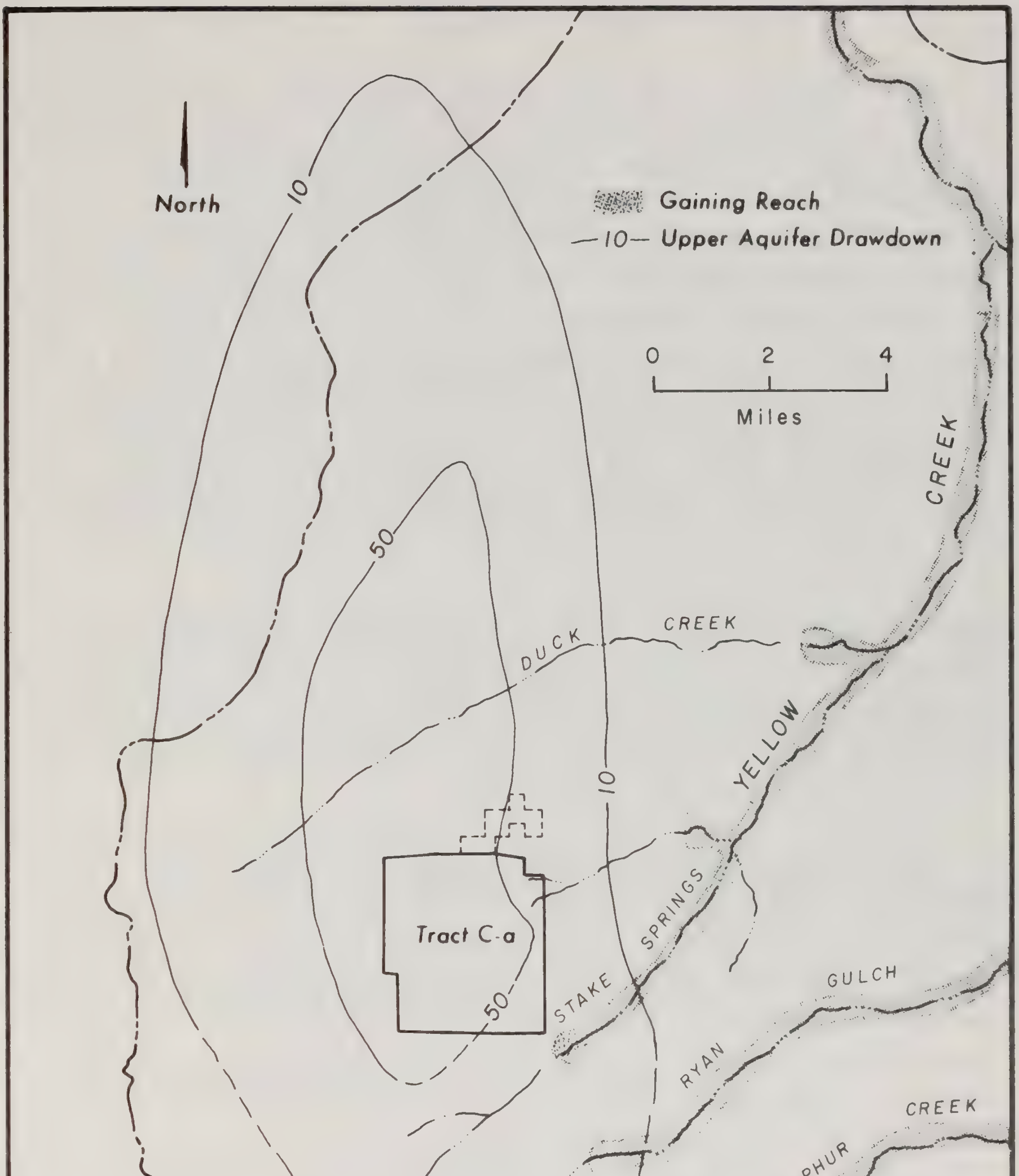



**Figure 8-6-1**
**Maximum Area Potentially Affected by Cone of Depression**

of injection on Upper Aquifer water quality are not significant and the regional geohydrologic system will not be significantly altered.

A computer simulation of the Upper Aquifer ground water system in the tract vicinity has been used to project the areal extent of drawdown from dewatering under the worst expected conditions. The simulation does not include structural controls in the aquifers which apparently act to limit the spread of the drawdown cone. Therefore the drawdown predictions are very conservative. Figures 2-4-28, 2-4-29 and 2-4-30 present drawdowns predicted by this model at various stages of the Lurgi Demonstration Project. Figure 8-6-1 illustrates the greatest expected extent of drawdown predicted by this model at any time during the Lurgi Demonstration Project as well as areas in which such drawdown would be expected to affect spring flows. This figure illustrates that, based on the State Engineer's study, the injection program should be sufficient to prevent any significant adverse impacts to spring flow.

Baseline studies conducted on springs in the Tract C-a vicinity provided inconclusive evidence that some springs west and north of the tract are also possible discharge points for the Upper Aquifer. Springs in these areas will be monitored by RBOSC during the demonstration to determine if dewatering is having a significant impact on spring flow.

C. Disposal of Mine Water - Potential Impacts - As noted, water will be removed from both the MIS mine and the surface mine. Such water will be stored in on-site ponds until it is utilized or lost via evaporation or disposal. Water from the surface mine facility will normally be injected into the Upper Aquifer. However, to maintain flexibility in water management, an NPDES permit will be obtained to permit occassional discharge of this water to Dry Fork. Water from the MIS mine will be injected into the Upper Aquifer or discharged to Corral Gulch. The removal and eventual use or disposal of this water potentially alters the natural hydrologic system in five ways.

1. Evaporative Water Loss - While the water is stored on the surface, all or part of the stored volume will be lost to evaporation. Therefore, the amount of water present in the site hydrologic system will be reduced slightly in order to treat effluent in ponds.

2. Increased Streamflow Volumes - The occasional surface discharge of stored water will generate streamflow which would not naturally occur, increasing long-term surface flow volumes. If this discharge were not controlled, peak flows in excess of natural peak flows could occur and increase channel erosion.

3. Increased Sediment Concentrations - Water flowing in the mines will cross disturbed areas, accumulating sediment loads. This increase in total suspended solids reduces options for potential use of that water and, if introduced to natural drainage systems untreated, might have an adverse impact on the existing aquatic ecosystem or downstream water use.

4. Altered Streamflow Water Quality - The occasional discharge of water originating from the Upper Aquifer into the surface water system will result in mixing water of slightly different quality, changing stream flow quality characteristics. It should not alter aquatic ecosystems or impact downstream water use.

5. Increased Alluvial Ground Water Storage - The increased long-term surface flow resulting from the occasional discharge of Upper Aquifer water will create increased water storage in the alluvial aquifer. This, in turn, may result in locally increased spring flows, fed by the alluvial aquifer, or in the establishment of marshy areas in the alluvium.

D. Disposal of Mine Water - Mitigative Measures

1. Injection - The water lost to evaporation will have primarily originated from the Upper Aquifer. As previously noted, injection of surplus water back to the Upper Aquifer will be the primary means of disposal. Such injection will ensure that water loss will be minimized and resulting drawdowns will be contained to areas where they will not create signficant

adverse impacts. Therefore, loss of water by evaporation from the mine system treatment lagoons will not have a significant impact on the regional hydrology.

2. Settling Treatment - All water removed from the mines will be retained in treatment ponds to reduce sediment loads. On the infrequent occasions when such water may be discharged to Dry Fork, discharge will not occur until peak sediment concentrations meet NPDES effluent standards. This will be sufficient to eliminate any potentially significant impacts on the natural system from increased sediment loads.

3. Streamflow and Peak Flow Regulation - On those infrequent occasions when discharge to Dry Fork occurs, discharge rates will be regulated so that the flow capacity of the natural channel will not be exceeded; therefore, the increased stream flow will not adversely impact the channel. The increased volumes discharged will either be lost to evaporation, or be applied to some beneficial use by nearby down stream users.

4. Mixed Water Compatibility - The discharge water for the surface mine and the MIS mine is expected to have TDS concentrations less than a maximum concentration of 950 mg/l. Discharges may occur into Dry Fork about two miles above its confluence with Corral Gulch. The average TDS concentration at the monitoring station in Corral Gulch nearest the Dry Fork confluence has been 820 mg/l. The proximity of these values negates the need for mitigative measures above those measures provided by the natural system.

5. Increased Alluvial Ground Water - Any increase in alluvial ground water due to infrequent discharge of water removed from the mine system will probably result in increased sub-irrigation of vegetation and possibly in increased spring flows. Both effects will improve the area in terms of wildlife habitat and grazing capacity, and may be viewed as beneficial impacts. Therefore no mitigative action is necessary.

E. Sanitary Water Disposal - Potential Impacts - Water from the natural system will be used to provide sanitary facilities at the mine site. If water utilized for such purposes were discharged, untreated, to the natural system, aquatic ecosystems and downstream water use might be affected.

F. Sanitary Water Disposal - Mitigative Measures - Water utilized for sanitary purposes at the mine sites will be directed to treatment plants to reduce contaminants to levels which will not significantly impact aquatic ecosystems or downstream use. Effluent water quality is expected to be similar to that of the existing MIS treatment facility.

G. Disruption of the Alluvial Aquifer - Potential Impacts - As previously noted, the construction of the mine and access ramp will encroach upon the alluvium in Dry Fork and East Gulch; a portion of this material will be removed during excavation.

H. Disruption of the Alluvial Aquifer - Mitigative Measures - Observation wells completed in the mine area alluvium indicate that the alluvium is unsaturated; however, during periods of high infiltration and surface flow in the channel of Dry Fork, a saturated zone temporarily may be created in the alluvium. The surface mine will remove a minimal zone of the alluvium along the south flank of Dry Fork. The removed alluvium constitutes less than 5 percent of the alluvial section along the mine. Since 95% of the alluvium, including the maximum thickness, will not be affected by mining, and because the saturated condition of the alluvium is transient, ground water losses from the alluvium into the pit will be nominal, if occurring at all, and not require special consideration.

I. Increased Aquifer Storage - Potential Impacts - Upon completion of surface mining, the mine will be refilled with removed overburden, covered with topsoil and reclaimed. The replaced overburden will be compacted. However, it will probably not be compacted to its original density, creating an area with a higher porosity and greater water storage capacity than its original condition or that of the surrounding area.

J. Increased Aquifer Storage - Mitigative Measures - Reclamation of the surface mine will create permeability and ground water storage capability in the Upper Aquifer in the mine area which are greater than those of the natural system. Therefore, drawdown recovery will require more natural water inflow and a longer time than would be necessary under non-mined conditions. Eventually, however, the water inflow will fill the depressed areas and the piezometric levels in the reclaimed mine area will return essentially to those of natural conditions.

Because the reclaimed mine area will be surrounded by undisturbed aquifer material with the lower natural permeabilities, inflows and outflows at the mine will be controlled by natural permeability values. Therefore, once recovery has occurred, the apparent permeability of the reclaimed mine area will also be that of the natural system, and regional aquifer flow regime will return to that of pre-mining conditions. Since the fill material is naturally occurring local material, it should be in chemical equilibrium with the local ground water.

## 6.3 LURGI PROCESSING SYSTEM - POTENTIAL IMPACTS AND MITIGATIVE MEASURES

A. Consumptive Use - Potential Impacts - As previously noted, there will be water losses from evaporation in the Lurgi process. With the exception of small amounts of residual shale water freed by processing, all water lost will have been provided by the natural hydrologic system.

B. Consumptive Use - Mitigative Measures - Two measures will be taken to minimize the impact of water loss from the natural system.

1. Injection - The water consumed by Lurgi processing will be drawn primarily from the Upper Aquifer with insignificant amounts being drawn from precipitation directly on the Lurgi facilities. As previously noted, injection will be used to ensure that losses from the aquifer will be as small as possible, and that resulting drawdowns will be contained in areas where they will have no significant adverse impacts.

2. Water Conservation - The Lurgi system has been designed to reuse waste streams generated by processing. This reuse reduces the demand for water from the natural system.

C. Increased Peak Flows and Sediment Loads - Potential Impacts - The Lurgi facilities will receive direct precipitation. Under normal conditions, a portion of this water would infiltrate into the soil, another portion would evaporate and the remainder would run off. The presence of the Lurgi facilities, however, will alter the natural system. Disturbed areas which are not directly related to the process operation, such as the haul road, will generally have lower infiltration rates than natural conditions, converting a larger percentage of the precipitation to runoff and creating larger peak flows. Because this flow passes over disturbed areas, it will probably accumulate sediment load in excess of those present in the natural system. If these sediment loads are introduced to the natural streams, they might have an adverse impact on the existing aquatic ecosystem, on stream channel hydraulics and on downstream water use.

D. Increased Peak Flows and Sediment Loads - Mitigative Measures - All runoff from disturbed areas associated with the Lurgi processing facility will be retained in a treatment pond to reduce sediment loads, and will not be discharged until peak sediment concentrations are below NPDES effluent standards. This will be sufficient to eliminate potentially significant impacts on the natural system from increased sediment loads. Because the discharge will be regulated, outflows will be controlled so that the flow capacity for the natural channel will not be exceeded. Therefore, this discharge will not increase natural peak flows or accelerate channel erosion.

E. Degraded Water Quality - Potential Impacts - After being utilized in processing, a portion of the natural water supplied from the Upper Aquifer or from precipitation will accumulate as a waste stream. The quality of this stream will have been degraded by contaminated runoff into the storm drainage system, utility washdown and ammonia stripper condensate. This water will generally be consumed by cooling demands, and it cannot be discharged without being treated to prevent a potential adverse impact on aquatic ecosystems and downstream use.

F. Degraded Water Quality - Mitigative Measures - Tertiary water treatment will be a standard procedure for the process waste stream containing contaminated runoff, utility washdown and ammonia stripper condensate. Such treatment will be provided whether the water is used for cooling purposes or, as may infrequently occur, is discharged. Water of this quality will not significantly impact aquatic ecosystems or downstream use.

## 6.4 PROCESSED SHALE DISPOSAL SYSTEM - POTENTIAL IMPACTS & MITIGATIVE MEASURES

A. Consumptive Use - Potential Impacts - The disposal process will require the consumption of water for shale moisturization. This demand will be supplied by ground water from the water supply well and mine systems, either directly or via the Lurgi processing plant, and will not be available for replacement in the natural system.

B. Consumptive Use - Mitigative Measures - Two mitigative measures will be applied to minimize the impact of water loss from the natural system.

1. Injection - The consumed water will be drawn from the Upper Aquifer. As previously noted, injection will be used to minimize water losses from the aquifer and to limit resulting drawdowns to areas where they will create no significant adverse impacts.

2. Water Conservation - The processed shale disposal system has been designed to use waste stream water from the Lurgi processing facility. Additional fresh supplies from the ground water reservoir will be minimal and will primarily be used for limited demonstration experiments. This reuse of waste water minimizes the water demand from the natural system.

C. Increased Peak Flows and Sediment Loads - Potential Impacts - The disturbed areas, such as topsoil stockpiles and haul roads, which are associated with the processed shale disposal area, will probably have lower infiltration rates than the natural soils. For a given precipitation event, this will lead to increased runoff and higher peak flows than those which would naturally occur. Because this flow passes over disturbed areas, it will probably accumulate a sediment load in excess of that occurring in the natural system. This increased sediment load could have an adverse impact on the existing aquatic ecosystem and on downstream use if it were not treated.

D. Increased Peak Flows and Sediment Loads - Mitigative Measures - All runoff from disturbed areas associated with the processed shale disposal system will be retained in a treatment pond to reduce sediment loads, and will not be discharged until peak sediment concentrations meet NPDES requirements. This will be sufficient to eliminate potentially significant impacts on the natural system from increased sediment loads.

After settling treatment, the collected runoff from the disturbed areas will be discharged into the natural drainage. However, because the discharge will be regulated, outflows will be controlled so that the flow capacity for the natural channel will not be exceeded. Therefore, this discharge will not increase natural peak flows or adversely impact the channel. The increased total volume of flow will be consumed by increased evaporation or additional beneficial utilization. In any case, the presence of increased water volumes from this source will be infrequent, small, and will not cause adverse hydrologic impacts.

E. Degraded Water Quality - Potential Impacts - Precipitation will fall on the processed shale pile. The resulting runoff may be contaminated due to contact with the processed shale material. Also, processed shale leachate experiments will generate a potentially contaminated flow stream that could impact stream water quality if it were discharged.

F. Degraded Water Quality - Mitigative Measures - Leachate and runoff generated by precipitation on unreclaimed processed shale or by processed shale leachate experiments will be collected and directed to appropriate ponds. The isolation of this water from the natural system until its quality can be determined, and an acceptable use or disposal mechanism can be selected, will prevent impacts to the natural ecosystem.

## 6.5 MISCELLANEOUS DISTURBED SYSTEMS - POTENTIAL IMPACTS & MITIGATIVE MEASURES

Mining and processing activities will require various on-site disturbances separate from the project systems. These disturbances include haul roads, topsoil stockpiles, overburden stockpiles and ore stockpiles.

A. Increased Peak Flows and Sediment Loads - Potential Impacts - The disturbed areas will probably have lower infiltration rates than the natural soils. Therefore, a given precipitation event will generate more runoff from the disturbed areas, increasing runoff volumes and peak flows and reducing the amount of water entering the soil moisture reservoir.

B. Increased Peak Flows and Sediment Loads - Mitigative Measures - All runoff from the miscellaneous disturbed areas, except those associated with ore stockpiles, will be retained in treatment ponds to reduce sediment loads before being discharged. This water will not be discharged until peak sediment concentrations are below NPDES effluent standards. This will be sufficient to eliminate potentially significant impacts on the natural system from increased sediment loads.

After settling treatment, the collected runoff from disturbed areas, other than those associated with raw shale ore, will be discharged into the natural drainage. However, because the discharge will be regulated, outflows will be controlled so that the flow capacity for the natural channel will not be exceeded. Therefore, this discharge will not increase natural peak flows or adversely impact the channel. The increased total volume of flow will be accounted for by increased evaporation or additional beneficial utilization. In any case, the presence of increased water volumes will be infrequent, small, and will cause no adverse hydrologic impacts.

C. Degraded Quality - Potential Impacts - The flow of runoff over the ore stockpiles may produce water of lower quality than runoff from natural soils. Such flows will collect increased sediment loads as they cross the disturbed areas. In addition, flow across the ore stockpiles may collect additional contaminants that could adversely affect stream water quality.

D. Degraded Quality - Mitigative Measures - All runoff from raw ore stockpiles will be collected and directed to holding ponds. The quality of this water will be determined and will either be utilized in project operations or evaporated, as appropriate. The isolation of this water from the natural system will prevent impacts to the natural system.

CHAPTER 7

ASSESSMENT OF CULTURAL RESOURCES IMPACTS

A 100 percent survey of the cultural resources of Tract C-a and vicinity was conducted in 1976. A description of this survey is included in Section 7, Chapter 12, Protection of Objects of Historic and Scientific Interests. The results of the survey are contained in the report "A Cultural Resources Survey for the Rio Blanco Oil Shale Project in Rio Blanco County, Colorado" (RBOSP 1976c). Copies of this report are on file at RBOSC offices in Denver, at the office of the State Historic Preservation Officer and at the OSO.

Based on data from the cultural resources survey, the Bureau of Land Management prepared a Determination of Effect which concluded that no adverse effect to the site(s) would result if proper mitigation procedures were followed. Concurrence with these findings was received from the State Historic Preservation Officer on February 3, 1977.

All of the areas involved in the Lurgi Demonstration Project were included in the 1976 survey area. The sites identified in the 1976 survey were classified as primary, secondary, or tertiary according to a numeric system based on the type and number of artifacts located. No primary or secondary cultural resources sites were identified in the vicinity of any of the proposed facilities. Only two of the tertiary (minor) sites identified by the survey will be directly impacted by the proposed developments. These sites were cleared in the 1976 survey, and no subsurface artifacts are expected to be present. Therefore, no additional protection measures are warranted.

Based on the results of the 1976 survey and the determinations issued by the BLM and the State Historic Preservation Office, no adverse impacts to significant cultural resources impacts are anticipated as a result of the proposed Lurgi Demonstration Project. RBOSC requested confirmation from the State Historic Preservation Office (on October 30, 1980) that adequate cultural resources data have been collected for the Lurgi Demonstration Project area and that the existing clearance is thus applicable to those areas to be affected by construction and operation of the proposed project. Confirmation was received from the State Historic Preservation Office on November 17, 1980.

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## Section 9

# ENVIRONMENTAL MONITORING

# CHAPTER 1
# INTRODUCTION

## 1.1 OBJECTIVES

The RBOSC Environmental Monitoring Program for the Lurgi Demonstration Project is designed to:

- Fulfill the monitoring stipulations of the Tract C-a Oil Shale Lease.
- Fulfill the monitoring requirements of Federal, State, and local permits.
- Evaluate the success of RBOSC environmental protection programs (impact mitigation measures) by assessing the net impact of the Lurgi Demonstration Project.

The Tract C-a lease stipulates that a monitoring program shall be conducted before and during development operations, to provide 1) a record of changes from pre-development environmental conditions; 2) an ongoing check of compliance with lease provisions and applicable Federal, State, and local environmental control requirements; 3) timely recognition and notice of any adverse impacts; and 4) a factual basis for revision of lease stipulations. The monitoring program is designed to meet these stipulations as well as to satisfy the specific monitoring requirements requested by the OSO.

Development of the Lurgi Demonstration Project will extend over a number of years and will unavoidably result in impacts, or changes in the natural environment. Land will be disturbed for roads, mining and processing facilities, disposal areas, and ancillary facilities. Lurgi oil shale retorting will produce gaseous and particulate emissions. Dewatering of the mine area will be necessary to prevent subsurface seepage into the mine. RBOSC has assessed these potential impacts and has developed a variety of mitigation measures to lessen or prevent them. Section 8 of this document describes the impact assessment process. Section 7 describes the mitigation measures which were developed in response to that assessment.

The environmental monitoring program is also designed to provide an indication of how successful, in fact, the planned mitigation measures prove to be. To test the success of planned mitigation measures, RBOSC will monitor the type, severity, and duration of impacts which result from the proposed Lurgi Demonstration Project. The results of this monitoring will be the principal means of evaluating the adequacy of planned mitigation measures.

## 1.2 MONITORING PROGRAM DEVELOPMENT

Development of the environmental monitoring program involved determining the potential impacts and selecting methods to monitor these impacts.

Requisite to the measurement of development-related impact is a thorough knowledge of pre-development, baseline environmental conditions. This knowledge was obtained through a two-year baseline study. The results of this study are summarized in the Final Environmental Baseline Report (RBOSP 1977).

Environmental impacts to be monitored were selected on the basis of their significance, measurability, and indicator value. The introduction to Section 8 describes the criteria used to evaluate the significance of potential environmental impacts. RBOSC environmental specialists evaluated the measurability of those impacts which were assessed as significant. This measurability assessment was based on experience with baseline data analysis and results, consultation with a biostatistician, and the expert judgement of these specialists. The indicator value of the parameters associated with various impacts was also considered. The environmental baseline studies identified parameters with high natural variability or unexplained fluctuations which cannot be linked to an identifiable cause. These parameters were rejected in favor of more stable situations in considerations for monitoring, unless otherwise required by the OSO or other regulatory agencies.

Impacts which were assessed as significant, measurable, and having dependable indicator parameters were selected for monitoring. Some exceptions were made for impacts which are sensitive from a public or regulatory standpoint, and for specific monitoring requirements of the OSO. The selected impacts are believed to reflect environmental conditions on Tract C-a and the adjoining project area. If the data obtained from the monitoring program indicate that this is not the case, the program will be modified to reflect the new information.

Monitoring methods were selected by RBOSC environmental specialists based on their personal experience, on data collected during the baseline studies, and on knowledge of the type and format of data required by various agencies.

## 1.3 MONITORING PROGRAMS

Monitoring and/or evaluation programs were developed for the following environmental components:

- Air quality
- Meteorology
- Terrestrial ecology
- Aquatic ecology
- Hydrology
- Special studies
- Reclamation
- Ecological interrelationships

In addition to the above programs, specialized studies are conducted on an as-needed basis. The RBOSC Toxicology Study is an example. This study is briefly described in Chapter 7 of this section:

A scope of work was developed for each of the above programs. These scopes supply detailed information on specific objectives, and development of techniques designed to accomplish these objectives. In most cases, objectives involve determining whether certain project-related activities are significantly impacting the environmental component in question. A null hypothesis is usually stated in a format such that verification of the hypothesis determines that project-related activities are not significantly impacting the environmental component. Techniques designed to test the hypothesis are identified, as are monitoring schedules, locations, and data analysis procedures. Most of the monitoring programs utilize the control-treatment method to examine the relationship between project activities and changes in the environment of the project area. The monitoring program scopes of work are presented in their entirety in the RBOSC Modular Development Phase Environmental Monitoring Program, Revision 6.0 (RBOSC 1980), and are summarized in this document.

RBOSC has established quality assurance, data management, and reporting procedures as part of the environmental monitoring program. These procedures are summarized in this document, and are also described in more detail in the separate scope-of-work document referenced above.

## 1.4 QUALITY ASSURANCE, DATA MANAGEMENT, AND REPORTING PROCEDURES

A. Quality Assurance - The RBOSC Quality Assurance Program is designed to provide documentation that the environmental monitoring program is being conducted in accordance with the approved scope of work and in compliance with standard, approved scientific methods and procedures. In addition, the program must be as thorough and concise as possible, providing organized, accessible quality assurance information. The RBOSC program meets these needs.

The following procedures are the basic components of the RBOSC Quality Assurance Program.

- Use of program-specific field manuals by technicians to assure consistency in sampling
- Regular supervisory checks of all data sheets
- Verification of laboratory results by splits, ion balances, performance samples, and expert review
- Data Management input and subsequent checks
- Review of reports including verification of data in reports
- Periodic internal and external audits of quality assurance files and monitoring program procedures and data

Documentation of the above procedures is contained in a confidential documents file at the RBOSC Environmental Affairs Department office in Denver.

Documents retained in this file include monitoring program scopes-of-work, correspondence relating to the monitoring program, summaries of data collection techniques, records of data verification, reviews of monitoring reports, and results of monitoring program audits.

B. Data Management - The RBOSC Data Management System is an integrated process designed to enable rapid and relatively easy access and retrieval of data collected in the RBOSC Environmental Monitoring Programs. The data management system also functions as a quality assurance component, as data are reviewed and verified several times during the process. The data management system involves four activities: data collection, processing, analysis, and output.

Collection of the data is the most important aspect of the RBOSC data management system. Stringent, documented quality control procedures are implemented on all manual and digital data. This ensures credibility of the data base.

Processing of RBOSC environmental data is a multistep process that varies in complexity and sophistication with each of the monitoring programs. All data are sent to Denver and merged into a computerized data base. Data are then compiled on an appropriate storage medium and reviewed for accuracy and completeness, either by computerized editing routines or a RBOSC specialist.

Data analysis is performed as specified in the approved Monitoring Program Scope of Work. Evaluation, updating, pooling, and archiving of data are completed as part of this activity. Data analysis also involves testing and implementing new or previously defined analytical techniques. Interpretation of the analyses is also verified. This includes independent review and discussion between qualified scientists in each discipline.

RBOSC reporting requirements are such that the data management system must be flexible enough to generate the output necessary to meet these requirements. Data lists, tables, plots, and analysis output are generated and formatted as needed for the various reports required of RBOSC.

C. Reporting - Mid-year data reports are submitted to the OSO at the end of August of each monitoring program year. Mid-year reports contain reduced and raw data collected during the specified reporting period and short narrative descriptions of results. Where appropriate, (e.g., Air Studies Program) data are placed on magnetic data tapes. One copy of each edited tape is submitted for data collected during the previous six months when the mid-year report is submitted.

The year-end data report is submitted to the OSO at the end of March of each monitoring program year. Year-end reports contain raw and reduced data for the previous reporting period, yearly summaries, analyses and interpretations of the 12-month data set, and, where appropriate, comparisons between years, seasons, and other data sets (e.g., CDOW data). The year-end report is designed to continually update the data base for the tract. Trends are identified, anomalies are flagged, and long term evaluations are made. Development linked perturbations are identified and assessed as to significance. Possible mitigation procedures are recommended.

# CHAPTER 2
# AIR QUALITY MONITORING STUDIES

Monitoring of the ambient air quality of the Tract C-a study area was initiated in 1976 during the baseline studies, continued on a reduced scale during the interim period, and is again being measured extensively as tract development progresses.

An air quality dispersion modeling study (described in Section 7, Chapter 5) was conducted to determine areas of maximum pollutant concentrations emitted from the combined operations of the MIS and Lurgi surface retorts and other regional sources and to provide an estimate of these concentrations. It was shown that applicable air pollution standards will not be violated, and the highest concentrations are expected to occur to the west of the tract during relatively rare periods of sustained upvalley air flow.

A fugitive dust model analysis was also performed which indicated that particulate concentrations would be increased slightly or moderately by construction activity; topsoil removal; drilling, blasting and removal of overburden and shale ore; and processed shale disposal. Gaseous concentrations are also expected to increase slightly or moderately as a result of surface and underground retorting and increased human activity on the site.

A detailed description of the air studies monitoring program has been submitted separately in the RBOSC Modular Development Phase Environmental Monitoring Program, Revision 6.0 (RBOSC 1980). A summary of this program is presented in the following pages.

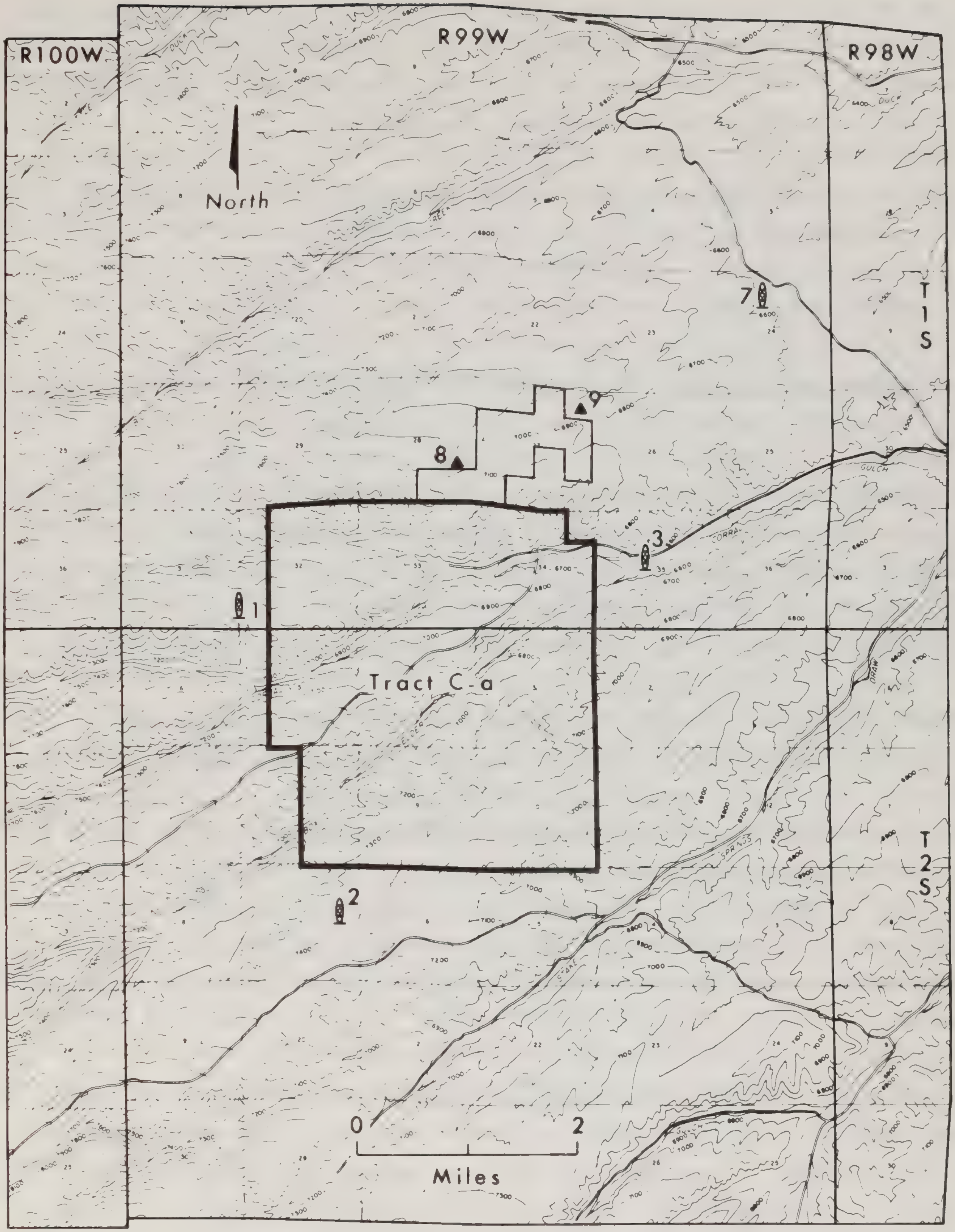
The air quality monitoring program, including sampling parameters, locations and schedules is outlined in Table 9-2-1. Station locations are also depicted in Figure 9-2-1. All sampling and data handling methods used in this program follow prescribed procedures found in the RBOSC Quality Assurance Manual.

TABLE 9-2-1

CURRENT AIR QUALITY MONITORING SCHEDULE

| Parameter | Location | Monitoring Dates[1] | Frequency |
|---|---|---|---|
| Sulfur Dioxide | Site 1 | Sept. 1977 | Continuous |
| | Site 3 | Jan. 1978 | Continuous |
| | Site 7 | Fall 1982 | Continuous |
| Hydrogen Sulfide | Site 1 | Sept. 1977 | Continuous |
| | Site 3 | Jan. 1978 | Continuous |
| | Site 7 | Fall 1982 | Continuous |
| Nitric Oxide | Site 1 | Sept. 1977 | Continuous |
| | Site 3 | Feb. 1980 | Continuous |
| | Site 7 | Fall 1982 | Continuous |
| Nitrogen Oxides | Site 1 | Sept. 1977 | Continuous |
| | Site 3 | Feb. 1980 | Continuous |
| | Site 7 | Fall 1982 | Continuous |
| Carbon Monoxide | Site 1 | Sept. 1977 | Continuous |
| | Site 3 | Jun. 1980 | Continuous |
| | Site 7 | Fall 1982 | Continuous |
| Ozone | Site 1 | Sept. 1977 | Continuous |
| | Site 3 | Nov. 1979 | Continuous |
| | Site 7 | Fall 1982 | Continuous |
| Particulates | Sites 1,2,3 | Dec. 1977 | Every 3rd Day |
| | Sites 7,8,9 | Summer 1981 | Every 3rd Day |

[1] Indicates date of startup for monitoring exclusive of baseline and interim studies which were conducted from 1975 - 1977.




Meteorological & Air Quality Monitoring Sites

▲ Hi-Vol Monitoring Sites

Figure 9-2-1
Meteorological & Air Quality Monitoring Sites

Sites 7, 8 and 9 are to be installed in 1981. The locations of these sites were determined using the results of air quality modeling, analyses of onsite meteorological data and examination of local topography. Final site locations will be determined in cooperation with the OSO.

Sites 4, 5 and 6 were established during earlier monitoring programs and they are no longer active.

## 2.1 AMBIENT MONITORING

A. Gaseous Constituents - As development proceeds, certain changes may occur in the ambient air quality due to facilities construction and the oil shale processing. The purpose of the air quality monitoring program is to provide a quantitative basis for evaluating any such changes in the ambient constituents. Ambient levels of specific gaseous constituents will be measured in conjunction with other air quality and meteorological data, which will allow analysis of the air quality impact of emissions on the tract. These data will also be compared to relevant State and Federal air quality standards.

Certain gaseous constituents (see Table 9-2-1) are monitored continually with automated instrumentation. The pollutants being measured were chosen either because tract operations are expected to release these pollutants, because data on these pollutants are necessary to characterize the air quality of the region or because monitoring is required by the terms of the Tract C-a lease or other environmental regulation. The data are recorded with an automatic data acquisition system with strip chart recorders as a backup system. The instruments are housed in strategically located, environmentally controlled trailers.

If concentrations exceeding lower instrument detection limits are recorded, data gathered on each monitored pollutant will be tested using techniques such as analysis of variance and multiple regression. It is difficult to specify the statistical techniques that will be most appropriate to analyze any air quality impacts which may occur, without first evaluating the yet-to-be-collected data set. Ultimate techniques to be used will be selected after review of suggested analyses described in the research literature and EPA publications, and after consultation with the OSO. A high degree of flexibility will be maintained in the data analysis to optimize utility and interpretation of the data.

B. Particulates - The normally low background particulate matter found during baseline may be disrupted by four sources of particulates during development. These include contributions from: 1) increased traffic on dirt roads around the study area, 2) construction activities, 3) shale ore production, crushing and overburden disposal and 4) processed shale disposal piles. The RBOSC monitoring program is designed to detect and quantify changes in the total suspended particulate matter as a result of these tract development activities.

Total suspended particulates are measured with high-volume samplers; particle size may be determined by specialized sampling techniques, such as cascade impactors, size-selective inlets or dichotomous samplers. Three total suspended particulate monitors have been in operation since the start of tract development. A 24-hour high-volume sample is taken at each of three sites (see Table 9-2-1) every third day. In order to measure potential impacts from the Lurgi Demonstration Project, the number of sites will be increased to six starting in June 1981.

The geometric means between data sets will be statistically compared using analysis of variance techniques. Another important analysis is the comparison of particulate data and on-site meteorological and project activity data, using multiple regression techniques. This allows inferences as to the sources and causes of high particulate concentrations. Because sources of particulates are expected to vary as development progresses, the data analysis will be utilized as a feedback mechanism to suggest adjustments to the monitoring program as well as to indicate the need for additional controls.

## 2.2 SOURCE EMISSION MONITORING

Because this project is a prototype in oil shale development, the specific requirements for source emission monitoring programs cannot as yet be defined. The source monitoring program will be designed to address the pollution control devices employed, stability of operation and the relative significance of each pollutant. Extensive discussions will be held with the OSO, EPA and CDOH as the engineering monitoring design progresses to develop an appropriate source monitoring program. Source monitoring and stack sampling that are needed to comply with the terms of permits and approvals will be included in the final design. Sampling ports and access facilities will be installed on each source controlled by air pollution control devices.

## 2.3 SPECIAL STUDIES

Techniques that go beyond the traditional air quality measurements will be employed to better characterize and understand the transport and dispersion of air pollutants in the area around the tract. Because the primary emphasis is on understanding the local meteorology and its influence on the pollutant plume, these special studies are presented in more detail in the meteorology section. These special studies will help to improve the knowledge of the air quality impacts of project-related emissions.

## 3.1 AMBIENT MONITORING

The primary influence and importance of meteorology at the tract is through its role in the dispersion of pollutants. The meteorological monitoring program, which is outlined in Table 9-3-1, will develop a data base to be used in atmospheric dispersion analysis and to determine if baseline meteorological conditions are similar during subsequent development. All sampling and data handling methods follow prescribed procedures found in the RBOSC Quality Assurance Manual.

Figure 9-2-1 illustrates the meteorological monitoring locations currently active or planned around the tract. Meteorological parameters (see Table 9-3-1) are monitored continuously by an automatic digital data acquisition system, with strip chart recorders as a backup system. Analyses identical to those of the baseline studies will be performed including annual and seasonal wind roses; annual and seasonal maximum, minimum and mean values; precipitation totals and events; frequency of occurrence of stability class derived from $\Delta T$ data; and joint frequency distribution of wind speed and distribution class on an annual basis. The data should serve as a vital data set for use in dispersion analyses and for use in special studies of the air quality data.

## 3.2 SPECIAL STUDIES

A. Visibility - The oil shale tracts are Federal PSD Class II areas. The closest Federal PSD Class I area is the Flat Tops Wilderness Area, some 80 kilometers east of Tract C-a. Since PSD Class I areas are legislatively protected from visibility degradation, changes in visibility are a concern. Visibility studies will be performed to provide measurements of visibility

TABLE 9-3-1

CURRENT METEOROLOGY STUDIES MONITORING SCHEDULE

| Parameter | Location | Monitoring Dates[1] | Frequency |
|---|---|---|---|
| Wind Speed (10 m) | Sites 1,2,3,7[3] | Sept. 1977 | Continuous |
| Wind Direction (10 m) | Sites 1,2,3,7[3] | Sept. 1977 | Continuous |
| Wind Speed (60 m) | Site 1 | Sept. 1977 | Continuous |
| Wind Direction (60 m) | Site 1 | Sept. 1977 | Continuous |
| Ambient Temperature (10 m) | Sites 1,2,3,7[3] | Sept. 1977 | Continuous |
| Temperature Differential (10-60 m) | Site 1 | Sept. 1977 | Continuous |
| Precipitation | Sites 1,2,3,7[3] | Oct. 1977 | By event |
| Barometric Pressure | Site 1 | Jan. 1978 | Weekly |
| Solar Radiation | Site 1 | Sept. 1977 | Continuous |
| Dew Point (10 m)[2] | Site 1 | July 1978 | Continuous |
| Snow Depth & Accumulation | Sites 1,2,3,7[3] | Nov. 1978 | By event |

1 Indicates date of startup for monitoring exclusive of baseline and interim studies which were conducted from 1975 - 1977.

2 Relative humidity data were collected between Sept. 1977 and July 1978

3 Site 7 to be activated during Summer, 1981

such that trends in the data can be distinguished from seasonal or diurnal fluctuations.

Visibility has been measured most recently (1978-1979) by photometric methods and telephotometry. Final EPA visibility regulations were published in November, 1980. No Federal reference methods of visibility monitoring have been promulgated, however. Consequently, the visibility monitoring program cannot be finalized at this time. It is anticipated that the cooperative program with Tract C-b will be continued and/or modified to reflect any changes neccesitated by new regulations.

B. Noise - Tract development will result in increased noise levels in the immediate vicinity of ongoing activities and near roadways as a result of increased traffic flow. Wildlife, especially big game animals, are expected to become acclimated to the noise within a short period of time and to resume normal activity patterns except in areas immediately adjacent to the mine site and areas where the noise source is erratic. The noise monitoring program will provide a data base on relative noise levels at various distances from sources on the tract. This information will be used by wildlife biologists in assessing the overall impacts of tract development on wildlife behavior.

The experimental design set up for the quarterly noise measurements for the MIS process consisted of 16 survey locations in concentric rings around the process site. This survey program will be altered to include measurements of the noise impacts from the Lurgi retort. One site will be established near the future location of the retort and six new sites will be established in concentric semicircles north of the Lurgi retort (Figure 9-3-1). Three existing sites located on the southern boundary of the tract will be deleted from the program, since they provide only redundant data available from other sites on background noise levels. The revised noise program will thus include 20 monitoring sites. Site locations will be adjusted, if necessary, to correspond with the location of terrestrial intensive study site 7, the location of which has not been finalized (See Section 9-4-2).

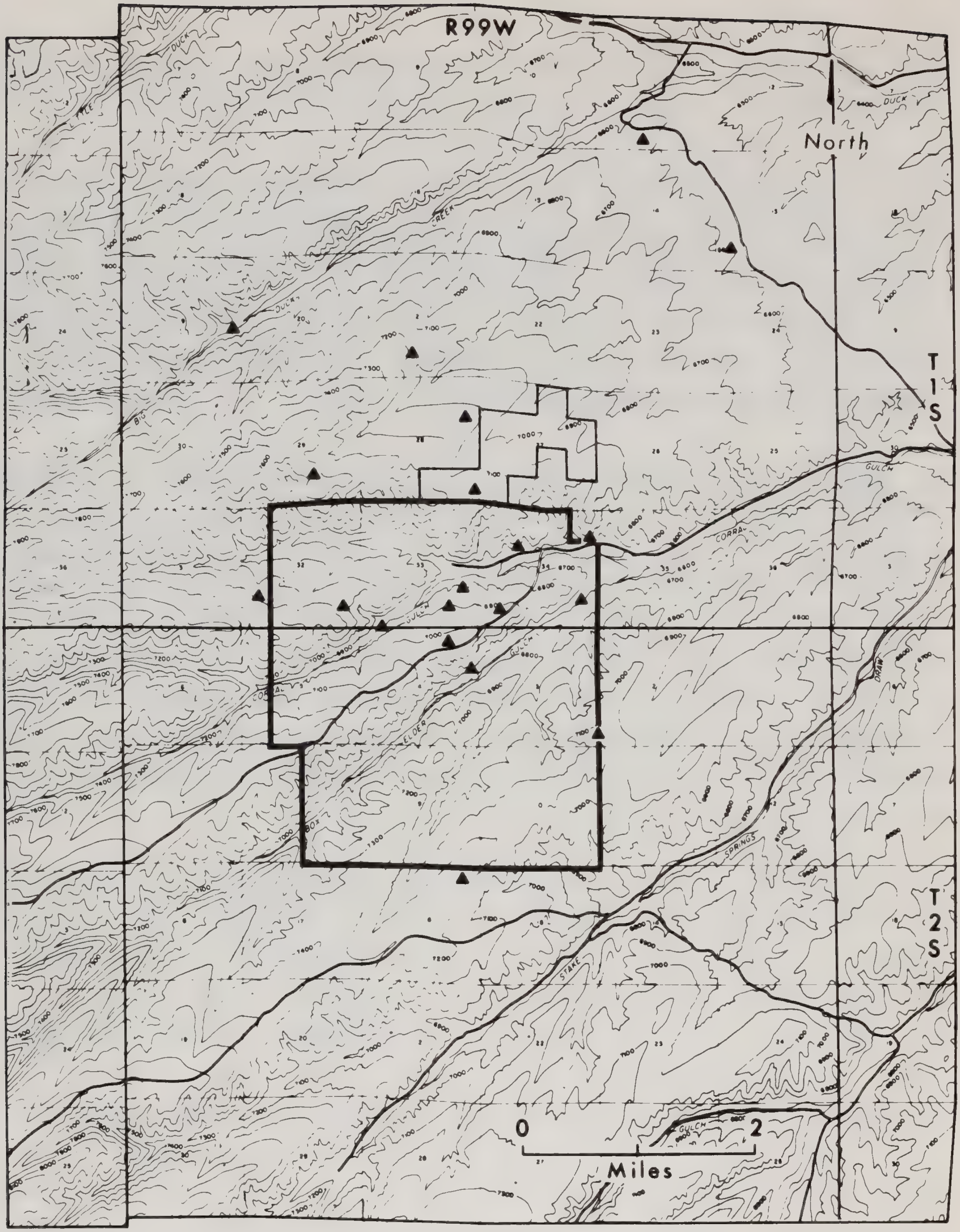



Figure 9-3-1
Environmental Noise Monitoring Sites

Each site will be flagged and monitored once each quarter. In addition to these quarterly measurements, opportunistic readings will be taken in construction or mining areas and at several selected off-tract locations during peak levels of activity to determine the sources and levels of noise, and the distances at which the sounds can be heard. Sound level readings will be taken with a General Radio Sound Level Meter, Type 1565B, or equivalent. Wind speed will be determined with a hand held anemometer and wind direction will be estimated with the aid of a compass.

C. Short-term Studies - Short-term studies such as smoke releases and tethersonde studies will be employed to develop a better understanding of the local meteorology and resulting dispersion characteristics in the immediate vicinity of Tract C-a. RBOSC expects to involve both the OSO and EPA in the planning of such studies. These studies will aid in understanding the complex meteorological interactions, and consequently improve the ability to predict the air quality impacts.

RBOSC's current plan is to use a small mobile laboratory to conduct smoke releases and tethersonde studies. Measurements will be taken at several locations around Tract C-a, including the MIS process site, the Lurgi retort process site (and the surrounding area), Corral Gulch, and the new meteorology/air quality monitoring site (Site 7). Experiments will be conducted, where feasible, during both nocturnal drainage conditions and daytime convective conditions during each season of the year to insure that the data are representative. The mobility of the instrument laboratory will allow sampling in a large number of areas.

Data analysis of the tethersonde measurements should greatly improve our understanding of the interaction among the surface and upper air flows, as well as the existence and extent of shear layers in the boundary flow regime. Photographic documentation of the smoke releases will improve our qualitative understanding of trajectory flows and dispersion patterns from selected point sources.

The RBOSC MDP terrestrial monitoring program, which is outlined in Table 9-4-1, was developed after examination of the results of an intensive two-year baseline program and a comprehensive assessment of the terrestrial impacts expected to result from oil shale development on Tract C-a. Environmental parameters selected are those which are either expected to be affected by developmental activities or are ecologically or politically important. Sampling locations for this program are illustrated in Figure 9-4-1. All field sampling and data handling methods utilized in this program follow documented quality assurance procedures. A summary of this program is presented in the following pages. A detailed description of the monitoring program can be found in the RBOSC Modular Development Phase Environmental Monitoring Program, Revision 6.0 (RBOSC 1980).

## 4.1 ABIOTIC MONITORING

A. Soils - Changes in trace metal content and conductivity levels are the most probable impacts of development on soils that can be measured with a reasonable degree of accuracy. Results of on-going research will be utilized in the design of these studies.

1. Trace Metals - Because the emissions are expected to be minimal during the operation of demonstration facilities, monitoring will not be undertaken until the commercial phase. Sampling will be initiated when commercial operations are initiated, to determine if releases of particulate matter from operations have appreciably affected the concentration of these metals in soils of the area and, if so, to determine if metals accumulated in soils have been taken up by plants.

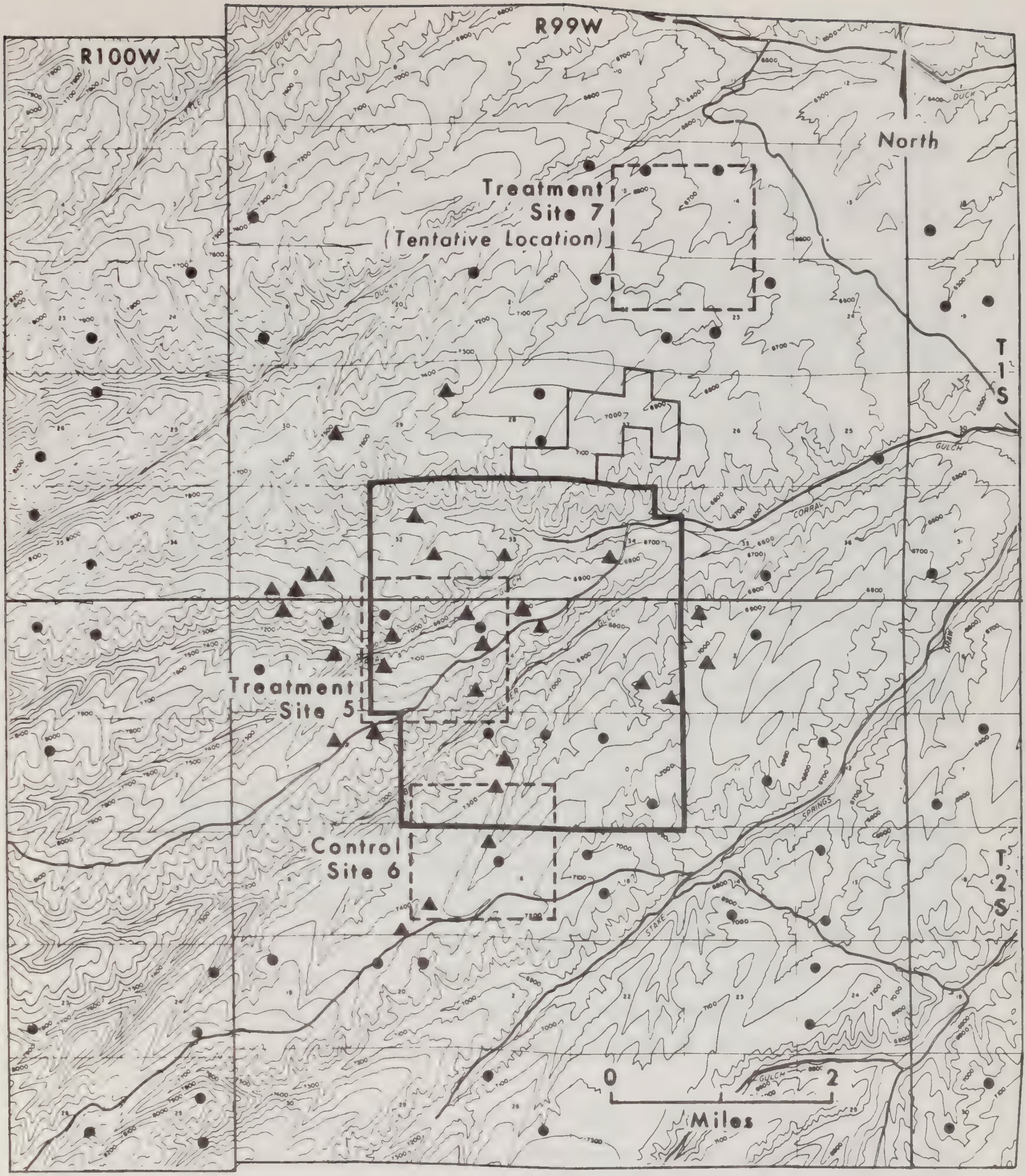
2. Conductivity - Salt drift from cooling towers may result in discernable changes in conductivity during commercial operations. However, concentrations are projected to be low during operation of the demonstration

TABLE 9-4-1

TERRESTRIAL STUDIES MONITORING SCHEDULE

| Parameter | Location | Start Date | Frequency |
|---|---|---|---|
| Soils Trace Metals Studies | | Commercial Operations | |
| Soil Conductivity Studies | | Commercial Operations | |
| Vegetation Mapping | Tract C-a & 5-mile Perimeter | Aug. 1978 * | Every 3rd year |
| Vegetation Stress | Anticipated impact areas | June-July 1979 | Annually |
| Vegetation Phytosociological Studies | Intensive Study Sites 5, 6 and 7 See Figure 9-4-1 | May-June 1979 | Once/3-yr period Rotation Basis |
| Range Productivity & Utilization | See Figure 9-4-1 | April 1978 (establish plots) | Annually (in Sept.) |
| Browse Condition & Utilization | See Figure 9-4-1 | May 1978 | Annually |
| Small Mammals | Intensive Study Sites 5, 6 and 7 See Figure 9-4-1 | May-June 1979 | Annually |
| Avifauna Studies | Intensive Study Sites 5, 6 and 7 See Figure 9-4-1 | May-June 1979 | Annually |
| Mule Deer - Density Studies | Tract C-a and 3 mile Perimeter | Sept. 1977 | Semi-annually (May, Sept.) |
| Mule Deer - Road Kill Studies | County Road 24 | Feb. 1979 | Weekly During Peak Migrations |
| Feral Horse Abundance | Tract C-a & 3-mile Perimeter | Jan. 1978 | Annually |

* 1978 aerial photography was conducted in August; however, subsequent flights will be scheduled for June-July




● Mule Deer Pellet Group Sample Unit
▲ Range-Browse, Productivity & Utilization Study Site
[ ] Intensive Study Sites

Figure 9-4-1
Terrestrial Ecology Monitoring Sites

facility. Therefore, conductivity studies will not be instigated until just prior (Table 9-4-1) to the commercial phase, since the source of impact will not exist until that time.

## 4.2 BIOTIC MONITORING

A. Vegetation - The following vegetation studies are designed to detect any changes which may result from construction, dewatering or waste disposal as indicated by the impact assessment for MIS and subsequent Lurgi activities.

1. Vegetation Type Distribution - This program provides data on the distribution of vegetation in the tract vicinity to detect any large-scale changes resulting from development. Color aerial photography (1 inch = 2,000 feet scale) of Tract C-a and the area within a 5-mile radius is taken at three-year intervals (Table 9-4-1). These photographs are compared to the RBOSC vegetation map (RBOSP 1977) and earlier color aerial photographs in determining if any distribution changes have occurred. This program is designed to provide qualitative information on vegetation distribution since statistical analyses are not appropriate.

2. Vegetation Stress - This study is designed to detect any vegetation stress which may occur from air pollutants or changes in the ground water or surface water regimes. Color infrared (CIR) aerial photography is taken on an annual basis (Table 9-4-1). Photographs are compared with those from previous years to assess variations in moisture regime and, to the extent possible, stress related to air pollutants. The vegetation stress study provides qualitative data over portions of Tract C-a and surrounding areas which may be affected by project operations.

3. Phytosociological Studies - The phytosociological studies are designed to gather species composition and cover data in the major vegetation types. Sampling is conducted on intensive study sites in May-June once every three years in a specific vegetation type on a rotating basis (Table 9-4-1). These intensive study sites are illustrated in Figure 9-4-1. Final siting of Site 7 will occur during the 1981 field season. The site will be located within the area of anticipated project impact, and in an area where sufficient pinyon-juniper and upland sagebrush stands are present to facilitate

small mammals and avifauna studies, which are also conducted within the intensive study sites.

During the initial sampling period in each type, density and cover of woody species and herbaceous cover is determined; thereafter, only herbaceous cover is measured. Photoplots are established at each belt transect to monitor changes in the vegetation. Photographs are taken annually during May from permanently marked locations. A two-way Analysis of Variance (ANOVA) is used to detect any differences in the percent herbaceous cover. Because the woody species data will be collected only once, these data are not amenable to ANOVA techniques and will serve as additional "baseline" information.

4. Range Productivity and Utilization - These studies are designed to provide information on vegetative production which can be used to compare range productivity before and during development. Forage is measured annually at the end of the growing season (August-September) by the double sampling method (Table 9-4-1). Range utilization is calculated although it cannot be used as an impact indicator since it is affected by stocking rates. The range productivity data are analyzed using a three-way ANOVA to compare predevelopment conditions with those during development.

5. Browse Condition and Utilization - These studies are aimed at providing browse use information for areas adjacent to Tract C-a because development on the tract may reduce browse availability, thus affecting animal distribution in these areas. Browse sampling is conducted annually in early May after deer migration (Table 9-4-1). A two-way ANOVA will compare browse use within each vegetation type and before versus during development. The browse condition data are not amenable to analysis by ANOVA techniques. These data are summarized and qualitatively compared between years.

B. Fauna - Of the faunal groups surveyed during the baseline period, the small mammals, avifauna and large mammals were deemed to be most important to the MDP monitoring studies; other groups have been excluded from the program because of their limited presence in the study area or the inability to adequately assess their numbers.

1. Small Mammal Studies - The small mammal studies are designed to determine species presence and habitat affinity, and to provide indices of relative abundance in important control and treatment habitats. Sampling is conducted in late spring or early summer for three or four consecutive days (Table 9-4-1). Species found in both the control and treatment area are ranked according to their relative abundance for each year of the program and for each habitat type. Spearman's Rank Order Correlation Coefficient is then used to determine the degree of independence between the control and treatment data. If significant differences between locations occur, a detailed analyses of other parameters sampled in these two locations will be initiated. This analysis will indicate if these differences reflect natural fluctuations due to changes in the soil and/or vegetation.

2. Avifauna Studies - The avifauna program is designed to determine species composition and relative abundance in control and treatment habitats. These habitats are the same ones studied in the soil, phytosociological vegetation and small mammal studies. Avifauna are monitored by means of a modified Emlen transect method (Emlen 1971 and 1977). Transects are run each spring (Table 9-4-1). Species found in both the control and treatment area are ranked according to their relative abundance for each year of the program and for each habitat type. Spearman's Rank Order Correlation Coefficient is then calculated to determine if the relative abundance of avifauna species has changed as site development progresses. If it appears that oil shale activities are adversely affecting the avifauna population, additional studies will be initiated.

3. Mule Deer Density - Consideration of the possible effects of Tract C-a oil shale development on mule deer is an integral part of RBOSC's Fish and Wildlife Management Plan. The objectives of RBOSC's mule deer monitoring program are to obtain an index of mule deer density in a designated area on Tract C-a. These indices will be compared with similar data from Game Management Unit 22, and, if possible, with mule deer densities within various portions of the study area. Pellet-group counts are made twice a year, once in the spring (May), and once in the fall (September), to determine the utilization of the area by mule deer (Table 9-4-1). Mule deer density estimates are calculated from pellet-group data as described by Overton

(1971). A three-way ANOVA is used to indicate differences in deer distribution between phase, seasons and among locations.

4. Mule Deer Road Kill Study - The Piceance Creek Basin is currently the center of a great deal of oil shale and natural gas energy development activity . This increased activity has resulted in increased traffic flows across mule deer migration routes. The objective of this program is to provide data on mule deer mortality along County Road 24 from Piceance Creek to Tract C-a for compilation and use by the CDOW. Mule deer mortality data are collected three times per week (Table 9-4-1) along this 13-mile route during prime migration periods (September to March). The program is designed to provide additional information to RBOSC for evaluating the effects of development on the mule deer herd and to assist the CDOW in compiling regional information on mule deer in the basin. The data are reported in semi-annual reports, but no attempt is made to analyze the data.

5. Feral Horse Abundance - The objective of feral horse monitoring studies is to provide qualitative information concerning the status of feral horses in the RBOSC study area. Feral horses on Tract C-a and within 3 miles of the tract boundary (same study area as mule deer) are counted annually in January (Table 9-4-1). Transects are flown by helicopter, and the location and number of horses observed are recorded. The aerial census data are supplemented by general observations (number; activity when observed e.g., watering, feeding) of horses recorded during other terrestrial ecology studies in May and September. The total number of horses seen in the study area is compared with the number estimated to be in the area by state and Federal agencies. This information provides a qualitative description of the status of feral horses in the study area.

6. Threatened and Endangered Species and General Wildlife Survey - Baseline and interim monitoring studies indicated that Tract C-a does not provide critical habitat for any State or Federally endangered species. Bald and golden eagles and peregrine falcons occasionally fly over the area. Sandhill cranes were spotted twice during baseline. RBOSC development activities are not expected to affect these birds. Observations of any threatened or endangered species will be reported to OSO and appropriate studies will be initiated as determined by RBOSC and OSO.

As part of the two-year Environmental Baseline Monitoring Program, studies of the aquatic ecosystem of Tract C-a and vicinity were conducted to inventory the aquatic biota and determine baseline characteristics of the aquatic resources. Aquatic biological studies were conducted in conjunction with limited physicochemical studies of surface water.

The analysis of the aquatic baseline data indicated that periphyton are the major primary producers in the study area and that benthic invertebrates are the primary aquatic consumers. While fish occur in lower Yellow Creek and the White River, other streams in the study area have ephemeral flow and do not support fish populations.

## 5.1 AQUATIC STUDIES DESIGN

A. Monitoring Program Development - The MDP aquatic monitoring program currently being conducted is designed to monitor potential impacts of MIS oil shale development. The development of this program involved a thorough analysis of environmental baseline data in which those aquatic factors likely to be impacted by development were identified. Modifications to the development plan and an increased understanding of the aquatic ecosystems in the area have led to program revisions. The revised program summarized herein reflects an assessment of combined impacts that may result from the construction and operation of the Lurgi demonstration facility and the ongoing MIS activities. For a more complete description of the aquatic studies monitoring program, see the RBOSC Environmental Monitoring Program, Revision 6.0 (RBOSC 1980).

B. Monitoring Program Methods - The MDP aquatic monitoring program is intended to provide an overall assessment of any changes which may occur in the aquatic habitat or biological communities on or near Tract C-a. Methodologies were selected which will most effectively obtain this end.

Sampling stations were chosen which are representative of the primary habitat types found in the area and whose locations will provide for early detection of any oil shale development impacts (see Figure 9-5-1). The Corral Gulch and Yellow Creek stations, as well as White River Station WR-2, will monitor the effects of RBOSC activities on the aquatic community downstream from the tract. White River Station WR-1 will serve as upstream control.

Samples will be collected three times a year (during the last two weeks of April, July and October) to allow comparison of seasonal changes. All measurements and samples will be taken concurrently. Parameters selected for study (see Table 9-5-1), corresponding to baseline period parameters, are those which are most likely to be influenced by development.

Physical, chemical and biological data will be used in concert to characterize the aquatic habitat and communities and define any changes which may occur. Such changes will be identified through the use of Analysis of Variance, Multiple Range Testing, and nonparametric Spearman Rank Order Correlation procedures. Should major changes be detected, additional studies will be initiated to determine the source of the change.

Quality control procedures as defined by the Quality Assurance Program will be implemented. Field sampling, laboratory work and data analysis will be conducted according to specific work instructions which conform to accepted methods for the collection, processing and analysis of aquatic data. These procedures are periodically audited by the RBOSC Quality Control Officer and OSO staff.

## 5.2 ABIOTIC MONITORING

A. Physical Measurements - A limited program for the collection and analysis of physical data has been developed (see Table 9-5-1) which will characterize the physical habitat conditions at each sampling site. These data will be evaluated using the previously described statistical methods, then utilized in conjunction with the chemical and biological sampling described below to indicate any changes which may occur in the aquatic system at or near Tract

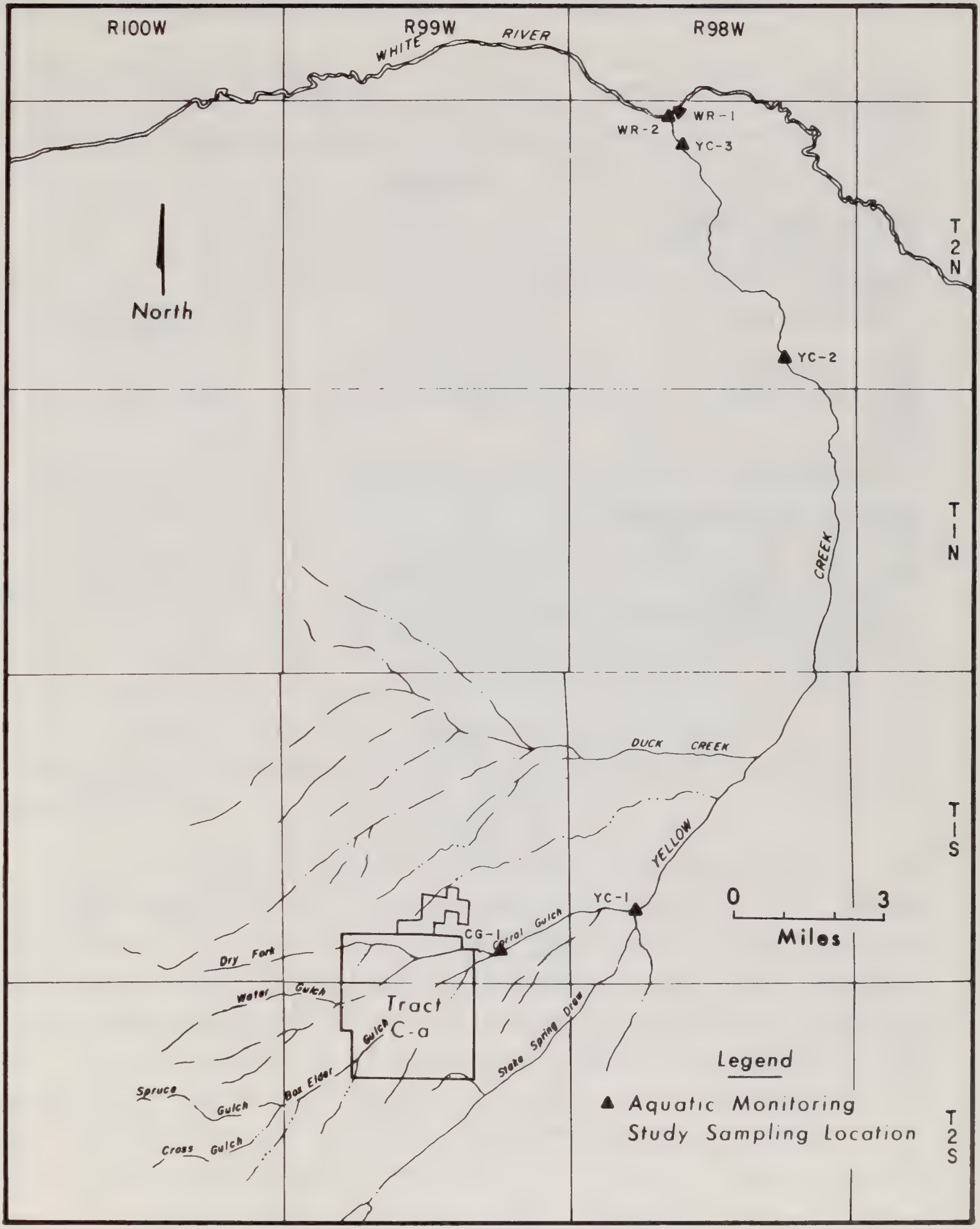



Figure 9-5-1
Locations of Aquatic Ecology MDP Sampling Sites

TABLE 9-5-1

MDP AQUATIC ECOLOGY STUDIES MONITORING PROGRAM SCHEDULE

| Parameter | Location | Frequency |
|---|---|---|
| | **Abiotic** | |
| Physical Measurements | | |
| Stream Velocity<br>Turbidity<br>Dissolved Oxygen<br>pH<br>Specific Conductance<br>Water Temperature<br>Depth<br>Width<br>Stream Substrate | Stations CG 1,<br>YC-1, YC-2, YC-3,<br>WR-1 and WR-2<br>(See Figure 9-5-1) | 3 times/year<br>(April, July, Oct.) |
| Water Quality Measurements | | |
| Basic Water Quality (BWQ) and Trace Water Quality (TWQ) as listed on page 9-6-3, plus Total Phosphate | Stations CG-1,<br>YC-1, YC-2, YC-3,<br>WR-1 and WR-2<br>(See Figure 9-5-1) | 3 times/year<br>(April, July, Oct.) |
| | **Biotic** | |
| Periphyton | Stations CG-1,<br>YC-1, YC-2, YC-3,<br>WR-1 and WR-2<br>(See Figure 9-5-1) | 3 times/year<br>(April, July, Oct.) |
| Benthos | Stations CG-1,<br>YC-1, YC-2, YC-3,<br>WR-1 and WR-2<br>(See Figure 9-5-1) | 3 times/year<br>(April, July, Oct.) |

C-a. A more extensive physical data collection is described in the Hydrology Monitoring Program (Section 9, Chapter 6).

B. Water Quality Measurements - A water quality sampling program will be implemented (see Table 9-5-1) to monitor those chemical constituents which the analysis of RBOSC baseline data indicated contribute most to the natural variability in water quality. Previously described statistical analyses of the data will be conducted to monitor year-to-year, seasonal and station differences, and natural and development-related variation. Water quality data collected in the hydrology monitoring program will be used to supplement aquatic monitoring data.

## 5.3 BIOTIC MONITORING

A. Periphyton - A periphyton sampling program (see Table 9-5-1) will monitor community characteristics in order to aid in identifying and documenting any changes in the aquatic ecosystems of the Tract C-a area. Eight replicate samples of periphyton will be taken from a known surface area of stream substrate which have relatively flat upper surfaces and are positioned at mid-depth in riffles. The pre- and post-development periphyton communities will be compared using several measurements of community structure and density. Statistical analyses will be employed to detect changes in relative abundance and diversity among sites and between baseline and the MDP monitoring period.

B. Benthos - A benthic invertebrate sampling program has been developed (see Table 9-5-1) which, like the periphyton monitoring program, will be used to aid in detection of any changes in the study area's aquatic system. Baseline data calculations indicate that only semi-quantitative sampling can be accomplished within the limits of time and habitat available near Tract C-a. Three replicate samples will be taken with a modified Hess sampler at each sampling site. Density and relative abundance of the benthos populations between the baseline and the MDP monitoring periods will be compared using previously described statistical analyses.

CHAPTER 6

HYDROLOGY MONITORING STUDIES

RBOSC has accumulated an extensive hydrologic data base over the period 1974 through 1980. This information along with results from numerous statistical analyses forms the basis of this hydrologic monitoring program. The hydrologic monitoring program is summarized herein. A detailed presentation of the program appears in the RBOSC Modular Development Phase Environmental Monitoring Program, Revision 6.0 (RBOSC 1980).

The basic program is designed to focus on potential impacts from site development activities. Monitoring stations have been grouped into networks according to their spatial likelihood of being impacted by development. Monitoring frequencies and constituents have been selected based on spatial variability and expected pollutant parameters, respectively.

The program has been separated into 1) surface system monitoring and 2) groundwater system monitoring.

The surface system monitoring program is designed to monitor potential impacts from various surface development activities and the ground water system program is designed to monitor subsurface impacts. The total program also considers the many interactions between surface and subsurface activities and surface and ground water systems.

In order to ensure consistent and reliable analytical data, RBOSC has developed a comprehensive quality control and quality assurance program, described in Chapter 1 of this Section. Central to the refinement of the program is the verification of initial monitoring station groupings and parameter selection. The experimental design and data base analysis will provide the basis for this refinement.

The final step in the development of this program was the selection of specific stations to monitor potential impacts from each major development activity. The final monitoring design describes each monitoring station selected for a specified development activity in terms of sampling frequencies and constituents and explanatory rationale. Because of the dynamic nature of the hydrologic system, changing development alternatives, regulatory requirements, and the size of the total program, specific details remain flexible and will be modified as appropriate.

## 6.1 BASIC PROGRAM DESIGN

A. Sampling Approach - The hydrology monitoring program is designed to focus on potential impacts from development activities consisting of the following:

- Dewatering/reinjection program
- MIS modular development area
- Open pit area
- Lurgi demonstration site

Monitoring networks have been designed for each site development activity. They are composed of (1) background or unaffected monitoring stations (Type I), (2) down-gradient, potentially-affected stations (Type II), and (3) down-gradient, but remote stations not likely to be rapidly affected, if at all (Type III).

Sampling frequencies are varied relative to the distance (temporal and/or spatial) from the development activity. More frequent sampling is justified for stations near the activity (Type II stations), whereas less frequent sampling is generally adequate for background (Type I) and remote, down-gradient (Type III) stations.

Constituents for monitoring have been selected from analysis of background data collected on and near Tract C-a and from expected constituents associated with development activities. Constituent selection criteria include the following:

- Constituents which are expected to exhibit significant changes should potential pollutant sources cause contaminants to be released to the hydrologic system.

- Constituents whose presence alone may indicate a surface or ground water impact.
- Constituents in the above categories for which accepted analytical methods are reasonably available.

Indicator constituents have been selected using an "enrichment factor" (EF) analysis. This research has identified possible concentrations of a particular constituent from a potential pollution source compared with ambient surface and groundwater concentrations. High EF values indicate high relative likelihood of detection of impact.

Based on these analyses, the basic water quality constituents listed below will be utilized as the basic set of parameters for monitoring. Trace water quality constituents shown will be measured less frequently to provide continuing baseline data.

**Basic Water Quality (BWQ)**

- General water quality measures
    - total dissolved solids
    - specific conductance
    - pH
    - alkalinity
- Major inorganics
    - calcium
    - magnesium
    - potassium
    - sodium
    - bicarbonate
    - carbonate
    - chloride
    - nitrate
    - sulfate
    - fluoride
    - ammonia
    - phosphate
    - boron
    - silica ($SiO_2$)
    - iron
- Dissolved organic carbon
- Trace elements
    - arsenic
    - selenium
    - vanadium
    - molybdenum
    - mercury
- Suspended solids
- Temperature
- Discharge rate or water level

**Trace Water Quality (TWQ)**

aluminum
barium
beryllium
bismuth
bromide
cadmium
chromium
copper
gallium
germanium
iron
lead
lithium
manganese
nickel
strontium
titanium
zinc
zirconium

B. Surface Monitoring - The locations of surface water monitoring stations are shown in Figures 9-6-1 and 9-6-2. The surface monitoring program includes the following elements:

- Surface flow and discharges
- Springs and seeps
- Impoundments/mine sumps/sediment and runoff control ponds
- Alluvial aquifers
- Erosion and sedimentation

Pre-development data and analysis and evaluation of potential sources of impact are bases for selection of types of samples to be collected and measurements to be made. Changes will be identified by comparison with baseline or pre-development data, by comparison with unaffected areas, and through the use of indicator constituents.

The following general pattern of sampling frequencies will be followed:

- Daily checks of leakage detection systems
- Weekly checks at nearby, down-gradient alluvial wells or surface stations
- Monthly or quarterly sampling at further down-gradient alluvial and surface installations

C. Deep Aquifer Monitoring - The locations of deep aquifer monitoring stations are shown in Figure 9-6-3. The deep aquifer monitoring program includes monitoring of both upper and lower bedrock aquifers. Major program elements include the following:

- Weekly - water levels
- Monthly - water levels, field measurements of water quality
- Quarterly - basic water quality analysis
- Annually - trace constituent analysis

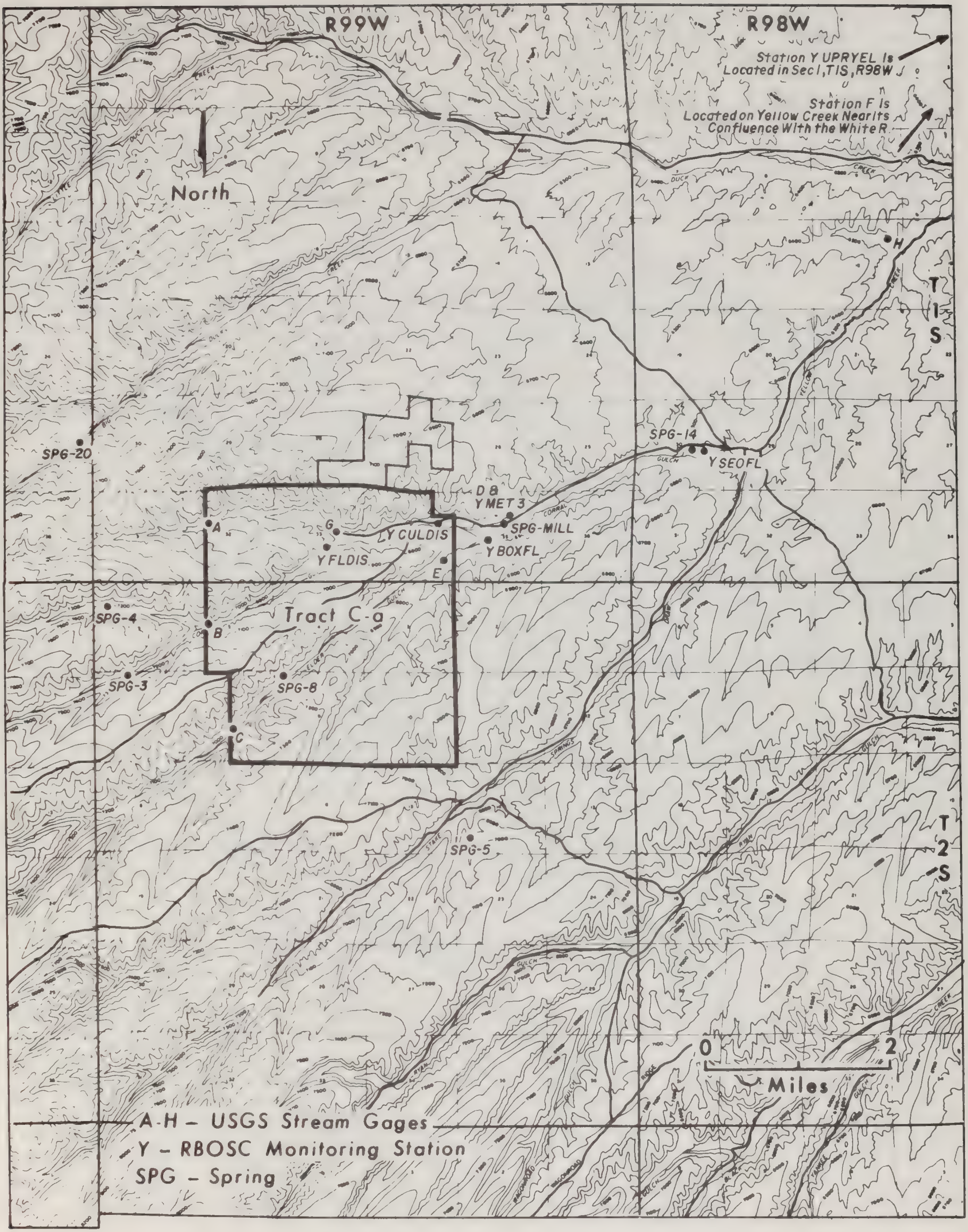



**Figure 9-6-1**
**Surface Discharge Monitoring Stations**

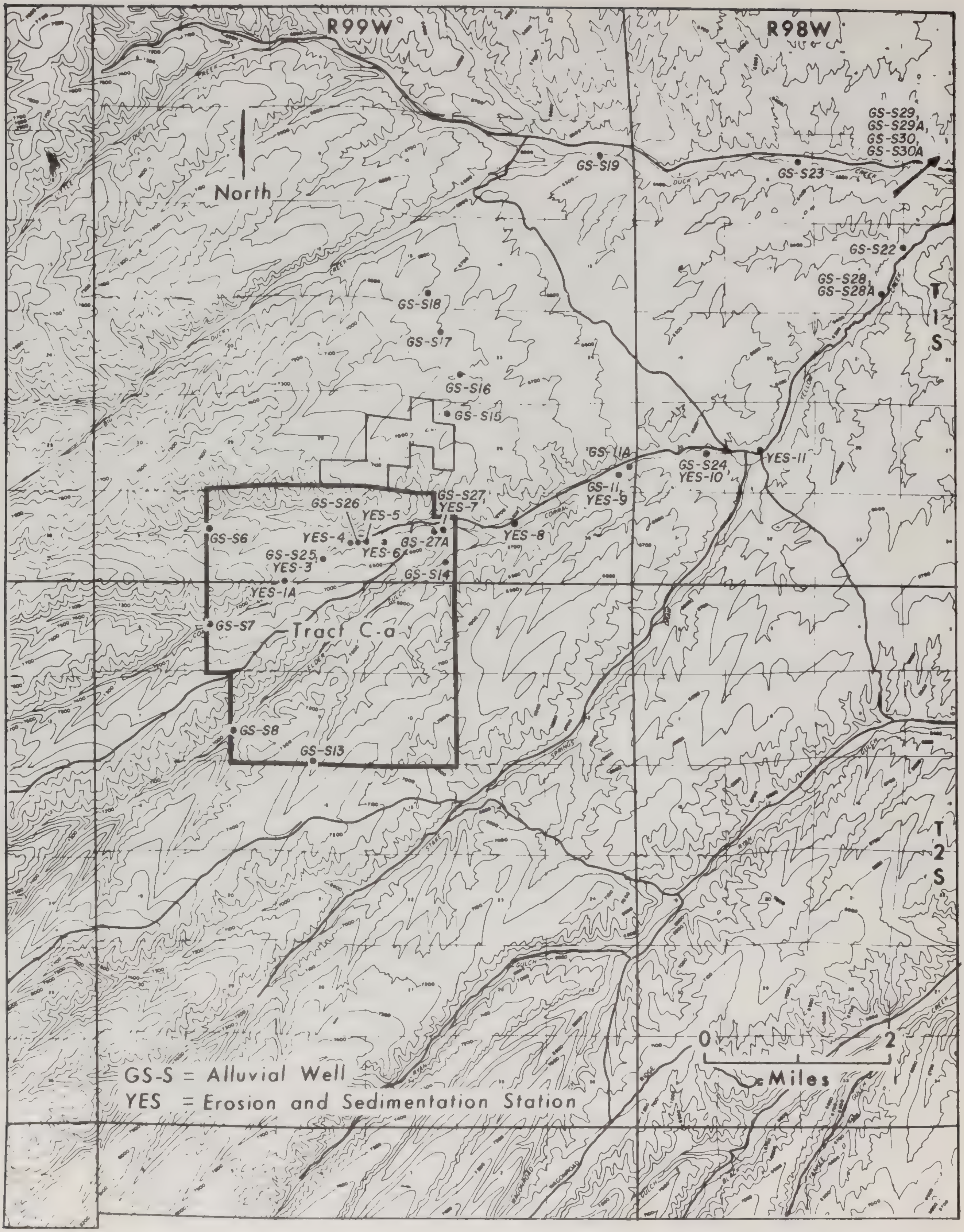



Figure 9-6-2
Alluvium Monitoring Stations

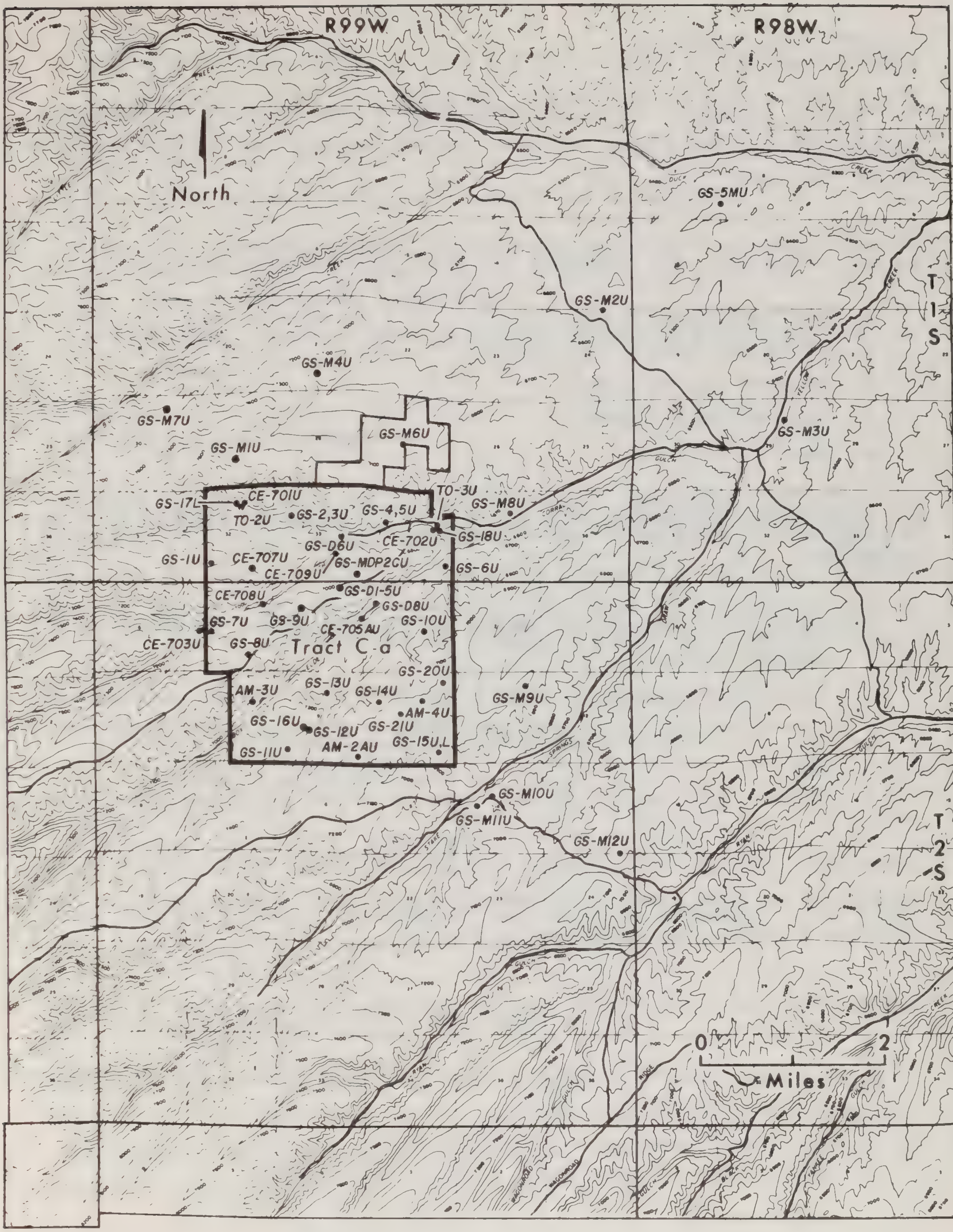



**Figure 9-6-3**
**Deep Aquifer Monitoring Stations**

## 6.2 ANALYTICAL APPROACHES

A. Chemical Analysis - Analytical methods to be used are those on EPA's list of approved test procedures for water quality analysis (44 CFR Part 233 and 44 CFR Part 244).

The laboratory quality control and assurance program includes:

- Instrument quality control
- Laboratory supplies and reagents
- Internal quality control
- External check samples
- Sampling tracking

B. Experimental Design/Data Base Analysis - The following analyses will be conducted:

- Statistical analysis of spatial variability to verify groupings of monitor stations
- Statistical analysis of temporal variability to examine importance of seasonal cycles and year-to-year changes over the period of monitoring
- Uniform description of the data to allow effective comparisons

Statistical analysis plans related to monitoring design include multivariate analysis of variance (MANOVA) and multiple range tests, cluster analysis, and principal components analysis where appropriate.

Output from statistical water quality analyses will yield the following:

- Analysis of variability with regard to time, location and the interaction of time and location
- Statistical summaries of treatment groups
- Partial correlations between chemical constituents

- Multiple range tests, useful for verification of station groupings when statistically significant interaction and main effects are observed

Routine regulating requirements will include the following:

- Descriptive statistics will be estimated for the report period
- Temporal and spatial variability
- Additional analyses when appreciable changes are observed from the above

6.3 SPECIFIC PROGRAM ELEMENTS

Specific monitoring programs for the four major development activities are presented in the following discussions. The orientation with regard to groupings of sample stations and sampling frequencies reflects the basic sampling approach defined in subsection 6.1A (Basic Program Design-Sampling Approach). Basic rationale for the station groupings and sampling frequencies are also provided for:

- Dewatering/reinjection/discharge program
- MIS modular development area
- Open pit
- Lurgi demonstration plant site

These specific programs represent not only sampling approaches but are also outlines for data analysis and interpretation.

A. Dewatering/Reinjection/Discharge Program

The major effects resulting from this development activity are changes in water levels or flows (when surface releases occur). In addition, general water quality measures (e.g. pH, temperature and specific conductance) are included in this hydrology monitoring program element.

The sampling program for dewatering/reinjection/discharge is summarized in Table 9-6-1.

B. <u>MIS Modular Development Area</u>

The hydrology monitoring program for the MIS development area is summarized in Table 9-6-2. The station classification scheme of Type I (control, unaffected), Type II (near field, potentially affected) and Type III (far field, potentially affected) is utilized to organize this monitoring activity.

C. <u>Open Pit</u>

The hydrology monitoring program for the proposed open pit area is summarized in Table 9-6-3. Only Type I (control) and Type II (near field, potentially affected) stations are identified for this program element. Far field stations are potentially affected by both MIS and Lurgi plant activities and thus are not considered acceptable for open pit monitoring.

A mine sump water reinjection program and associated upper aquifer monitoring are being designed. Consideration of these will be included in the open pit monitoring program. In addition, holes drilled in the alluvium and into the Uinta and Green River Formations for exploration and geotechnical purposes will be evaluated for use as monitoring sites.

RBOSC will initiate a special study in the summer of 1981 to select type II (near field) springs and/or seeps for inclusion in the open pit portion of the hydrology monitoring program. Detailed baseline information on springs to the north and west of the open pit site will be combined with field investigations and water quality analyses to identify those springs which can be expected to most immediately reflect any impacts due to pit dewatering. The study will be developed in cooperation with the OSO.

TABLE 9-6-1

HYDROLOGY MONITORING PROGRAM SUMMARY - DEWATERING/REINJECTION/DISCHARGE

| Station Class. | Monitoring Effect & Station Identification | | Sampling Program[1] D | W | M | Q | A |
|---|---|---|---|---|---|---|---|
| Type I Control | Springs & Seeps | | | | | Flow<br>FWQ[2] | |
| | SPG-3 | SPG-8 | | | | | |
| | SPG 4<br>SPG-5 | SPG-MILL | | | | | |
| | Deep Aquifer | | | | WL[3] | | BWQ[4]<br>TWQ[5] |
| | GS-M9U | AM-3U | | | | | |
| | GS-MIOU | | | | | | |
| | GS-M11U<br>GS-M12U<br>CE-708U | GS-9U<br>AM-2U | | | | | |
| Type II Near Field | Active Dewatering Wells | | Flow<br>WL<br>Press<br>FWQ | F,B[6] | | BWQ | TWQ |
| | GS-D6U | GS-D8U | | | | | |
| | Mine Seepage | | Flow | FWQ | | BWQ | TWQ |
| | MISUMP | | | | | | |
| | Active Reinjection Wells | | Flow<br>Press<br>FWQ | | | BWQ | TWQ |
| | YCOINJ<br>TO-2U<br>GS-4-5U<br>TO-3U | GS-6U<br>GS-20U<br>GS-21U | | | | | |
| | Discharge Sites/Streams | | Flow<br>FWQ | F,B | | | |
| | YFLDIS | | | | | | |
| | Deep Aquifer | | | | | | |
| | GS-D5U<br>GS-D1U<br>GS-D4U | | WL | | | | |
| | GS-MDP2CU | CE-702U | WL | | FWQ | BWQ | TWQ |

TABLE 9-6-1 (Continued)

HYDROLOGY MONITORING PROGRAM SUMMARY - DEWATERING/REINJECTION/DISCHARGE

| | | | | | |
|---|---|---|---|---|---|
| Type III Far Field | Streams | | | | |
| | E-USGS | | Continuous monitors, quarterly water quality | | |
| | YLDGEDGE | | X[7] | | |
| | Deep Aquifer | | | | |
| | GS-M2U<br>GS-M3U | GS-M5U | | WL | TWQ<br>FWQ<br>BWQ |
| | GS-10U[8]<br>GS-12U[8] | GS-11U[8]<br>GS-13U[8] | WL | | TWQ<br>FWQ<br>BWQ |

[1] D=Daily, W=Weekly, M=Monthly, Q=Quarterly, A=Annually

[2] FWQ=Field measurements including pH, temperature, conductivity; and for NPDES stations total suspended solids, and oil and grease

[3] WL=Water Level

[4] BWQ=Basic water quality, see text

[5] TWQ=Trace water quality, see text

[6] F=Fluoride; B=Boron

[7] Distance in miles from 84 Road crossing during discharge

[8] Type II WL; Type III Water quality

## Table 9-6-2

## HYDROLOGY MONITORING PROGRAM SUMMARY - MIS DEVELOPMENT AREA

| Station Class. | Monitoring Effect & Station Identification | | Sampling Program[1] | | | | |
|---|---|---|---|---|---|---|---|
| | | | D | W | M | Q | A |
| Type I Control | Streams | | Continuous monitors, quarterly water quality | | | | |
| | B-USGS | C-USGS | | | | | |
| | Springs and Seeps | | | | | FWQ[2]<br>BWQ[4] | TWQ[3] |
| | SPG-3<br>SPG-4<br>SPG-5 | SPG-8<br>SPG-14<br>SPG-MILL | | | | | |
| | Alluvial Aquifer | | | WL[5]<br>FWQ | | BWQ | TWQ |
| | GS-S7 | CS-S8 | | | | | |
| | Deep Aquifer | | | | WL | | BWQ<br>TWQ<br>FWQ |
| | GS-10U<br>GS-15U<br>GS-9U | GS-15L<br>CE-708U | | | | | |
| | Erosion & Sedimentation | | | | | Channel Cross-Section | |
| | YES-1A | YES-3 | | | | | |
| Type II Near Field | Streams | | Continuous monitors, quarterly water quality, Plus: | | | | |
| | D-USGS[6]<br>YCULDIS<br>YSEOFL | Y MET 3<br>YBOXFL | Flow<br>FWQ | | BWQ | | TWQ |
| | Impoundments | | | | | BWQ | TWQ |
| | MIS East Retention Pond<br>MIS West Retention Pond<br>MIS East Runoff Pond<br>MIS West Runoff Pond<br>East Shaft Settling Pond<br>Sour Water Ponds 1-7 | | WL<br>Vol<br>In&Out<br>Flow<br>FWQ | | | | |
| | YLEACH-1 | YPZR 1-4 | CK, FWQ if wet | | | | |
| | Alluvial Aquifer | | WL | FWQ | BWQ | | TWQ |
| | GS-S25<br>GS-S26 | GS-S27<br>GS-S27A | | | | | |
| | Deep Aquifer | | | WL | FWQ | BWQ | TWQ |
| | CE-709U<br>GS-MDP 2CU | CE-702U<br>CE-705AU | | | | | |
| | Erosion & Sedimentation | | | | | Channel Cross-Section | |
| | YES-4<br>YES-6 | YES-7<br>YES-5 | YES-8 | | | | |

# Table 9-6-2
## (Continued)

| Station Class. | Monitoring Effect & Station Identification | | Sampling Program[1] D | W | M | Q | A |
|---|---|---|---|---|---|---|---|
| Type III Far Field | Streams | | | | | | |
| | F-USGS | | Continuous USGS gaging station | | | | |
| | YUPRYEL | | | | Flow | BWQ FWQ | TWQ |
| | Alluvial Aquifer | | | | | | |
| | GS-S11 GS-S11A | GS-S24 | | | WL FWQ | BWQ | TWQ |
| | Deep Aquifer | | | | | WL | TWQ |
| | GS-M2U GS-M3U | GS-M5U | | | | | FWQ BWQ |
| | Erosion & Sedimentation | | | | | Channel | |
| | YES-9 YES-10 | YES-11 | | | | Cross-Section | |

[1]D=Daily, W=Weekly, M=Monthly, Q=Quarterly, A=Annually

[2]FWQ=Field measurements including pH, temperature, conductivity

[3]TWQ=Trace water quality, see text

[4]BWQ=Basic water quality, see text

[5]WL=Water level

[6]Monthly water quality

TABLE 9-6-3

HYDROLOGY MONITORING PROGRAM SUMMARY - OPEN PIT MINE SITE

| Station Class. | Monitoring Effect & Station Identification | | Sampling Program[1] | | | | |
|---|---|---|---|---|---|---|---|
| | | | D | W | M | Q | A |
| Type I Control | Streams | | Continuous monitors, quarterly water quality | | | | |
| | A-USGS | | | | | | |
| | Springs & Seeps | | | | | FWQ[2] BWQ[4] | TWQ[3] |
| | SPG-3 | SPG-4 | | | | | |
| | SPG-20 | | | | | | |
| | Alluvial Aquifer | | | WL[5] | FWQ | BWQ | TWQ |
| | GS-S6 | GS-S25 | | | | | |
| | Deep Aquifer | | | | WL | | FWQ BWQ |
| | GS-17L | | | | | | |
| | Two Duck Creek Wells (to be determined) | | | | | | TWQ |
| Type II Near Field | Streams | | Continuous monitors, quarterly water quality | | | | |
| | G-USGS (New) | | | | | | |
| | Sediment/Runoff Control Structures | | As per NPDES Permit requirements (to be defined by CDOH) | | | | |
| | Overburden Stockpile<br>Topsoil Stockpile<br>Haul Roads | | | | | | |
| | Mine Sump | | Flow | FWQ | | BWQ | TWQ |
| | Pit Sump Discharge | | | | | | |
| | Alluvial Aquifer | | | WL FWQ | | BWQ | TWQ |
| | GS-L-202 | | | | | | |
| | Deep Aquifer | | | WL | FWQ | BWQ | TWQ |
| | CE-701U<br>GS-M7U | GS-2-3U<br>GS-MIU | | | | | |
| | | GS-IU | | | | | |
| | | CE-707U | | | | | |

[1] D=Daily, W=Weekly, M=Monthly, Q=Quarterly, A=Annually

[2] FWQ=Field measurements including pH, temperature, conductivity

[3] TWQ=Trace water quality, see text

[4] BWQ=Basic water quality, see text

[5] WL=Water level

D. Lurgi Demonstration Plant Site

The hydrology monitoring program for the Lurgi plant site is summarized in Table 9-6-4. Alluvial and deeper holes being drilled for geotechnical and other reasons will be evaluated for possible inclusion in the monitoring program.

Impacts from the Lurgi plant operation and waste disposal facilities are best directly monitored at surface facilities and in components of the surface hydrologic system (e.g. alluvium and surface streams). Thus sampling frequencies for these areas are greater than for deep aquifer stations.

## 6.4 DATA MANAGEMENT AND QUALITY ASSURANCE

The RBOSC Hydrology Field Manual describes in detail procedures for obtaining field measurements for collecting and preserving water chemistry samples and for transcribing data in the field. The RBOSC Quality Assurance Officer conducts internal audits of the quality assurance file and the data management system and the OSO staff conducts field audits to insure that documented procedures are followed in the field. RBOSC cooperates with the OSO and the EPA in analysis of independent sample splits, performance samples and blanks to verify the accuracy of laboratory results.

RBOSC makes full utilization of data collected at USGS gaging stations by updating the existing data base.

Data processing is accomplished using established, documented, catalogue procedures. Results of data analyses are reported in year-end reports to the OSO.

TABLE 9-6-4

HYDROLOGY MONITORING PROGRAM SUMMARY - LURGI DEMONSTRATION PLANT SITE

| Station Class. | Monitoring Effect & Station Identification | | Sampling Program[1/] | | | | |
|---|---|---|---|---|---|---|---|
| | | | D | W | M | Q | A |
| Type I Control | Springs & Seeps | | | | | BWQ[2/] | TWQ[3/] |
| | SPG-3<br>SPG-4 | SPG-8<br>SPG-20 | | | | | |
| | Alluvial Aquifer | | | | WL[4/]<br>FWQ[5/] | BWQ | TWQ |
| | GS-S24 | | | | | | |
| | Deep Aquifer | | | | WL | | TWQ<br>FWQ |
| | GS-M1U | GS-M7U | | | | | |
| Type II Near field | Streams | | | | | | |
| | H-USGS (reactivate) | | Continuous monitors, quarterly water quality | | | | |
| | YUPYEL | | Flow<br>FWQ | | BWQ | | TWQ |
| | Impoundments | | WL<br>Vol<br>In&Out<br>Flow<br>FWQ | | | BWQ | TWQ |
| | Runoff ponds<br>Wastewater ponds | | | | | | |
| | Alluvial Aquifer | | | | | | |
| | GS-S15<br>GS-S16 | GS-S17<br>GS-S18 | | WL<br>FWQ | BWQ | | |
| | GS-S22 | GS-S23 | | | WL<br>FWQ | BWQ | TWQ |
| | Deep Aquifer | | | WL | FWQ | BWQ | TWQ |
| | GS-M6U | GS-M8U | | | | | |

TABLE 9-6-4

HYDROLOGY MONITORING PROGRAM SUMMARY - LURGI DEMONSTRATION PLANT SITE

| Station Class. | Monitoring Effect & Station Identification | | Sampling Program[1/] | | | | |
|---|---|---|---|---|---|---|---|
| | | | D | W | M | Q | A |
| Type III Far Field | Streams | | Continuous monitors, quarterly water quality | | | | |
| | F-USGS | | | | | | |
| | Alluvial Aquifer | | | | WL | BWQ | TWQ |
| | GS-S28 | GS-S29A | | | FWQ | | |
| | GS-S28A | GS-S30 | | | | | |
| | GS-S29 | GS-S30A | | | | | |
| | Deep Aquifer | | | | | WL | TWQ<br>FWQ |
| | GS-M2U | GS-M5U | | | | | |
| | GS-M3U | | | | | | BWQ |

1/ D=Daily, W=Weekly, M=Monthly, Q=Quarterly, A=Annually

2/ BWQ=Basic water quality, see text

3/ TWQ=Trace water quality, see text

4/ WL=Water level

5/ FWQ=Field measurements including pH, temperature, conductivity

CHAPTER 7

SPECIAL MONITORING STUDIES

## 7.1 TOXICOLOGY

A. Introduction - If a commercial scale oil shale operation is to be developed in this country, attention must be given to the potential hazard of oil shale-related products and by-products to health and the environment. A number of toxicology studies have been or are being conducted and additional research is proposed to assess the potential hazard of oil shale-related emissions, effluents, solid wastes, products and combustion products.

Historic data on workers in the Scottish and Russian oil shale industries indicate that the principal health hazard associated with this industry has been cancer of the skin associated with direct and prolonged contact with shale oil (Weaver and Gibson 1979). These studies, however, cannot be directly related to the oil shale industry in the United States because of vast differences in personal hygiene and mine safety precautions which are practiced here. Some scientific studies on the hazard of oil shale (Cox 1980) list fibrotic lung disease from exposure to siliceous dust, poisonous gases in the mine, cancer-causing compounds in shale retorts, and toxic substances in the processing operations as potential hazards of the developing oil shale industry. These hazards are typical of many mining operations, and a number of precautions are routinely taken to lessen such exposures. However, RBOSC is deeply concerned about these potential problems and is actively supporting research to assess and ameliorate these hazards.

The American Petroleum Institute (API) in 1976 initiated a program to investigate selected toxicological properties of raw and processed shale and raw shale oil. This study included evaluating the acute toxicity, chronic inhalation toxicity, carcinogenesis, mutagenesis and teratogenesis of raw shale oil and processed shale. Samples for these tests were collected from oil shale properties throughout the Colorado Plateau and included samples of raw shale from Tract C-a.

A Department of Energy (DOE) sponsored toxicology program was initiated in 1980 to collect more detailed, site-specific toxicology data at Tract C-a on raw oil shale and the products and by-products generated by the MIS processing of this shale. These studies are presently underway and will include the following:

- Detailed chemical and physical characterization of the source materials, process streams, products and by-products,
- Evaluation of potential health effects associated with MIS processing of oil shale,
- Biological testing of the compounds and materials associated with the MIS extraction procedure.

In addition to these aforementioned studies RBOSC is proposing to conduct supplemental toxicological tests on Lurgi materials to obtain data on the health hazards of these shale products and by-products. RBOSC will also encourage additional work by the DOE and API.

B. Objectives - The objectives of the DOE sponsored research and the proposed RBOSC toxicology studies are as follows:

- Characterize the chemical and physical properties of the raw shale and the products and by-products from the retorting processes, to determine the potential hazard of these materials.
- Determine the biological activity (carcinogenicity, mutagenicity, teratogenicity, and toxicity) of oil shale products and by-products to assess the potential worker exposures and environmental hazard.
- Develop an industrial hygiene program, control procedures and technology to mitigate or prevent worker exposure and environmental hazard.

C. Methods

1. API Program - RBOSC's parent companies worked closely with the API toxicology task force to define the oil shale research needs and to supply

the materials needed for testing. The test materials and procedures selected for this research program are shown in Table 9-7-1.

The toxicity program included the following elements: acute oral $LD_{50}$ in rats, acute dermal $LD_{50}$ in rabbits, skin and eye irritation in rabbits, skin sensitization in guinea pigs, and chronic inhalation toxicity tests. The carcinogenicity test procedure involved lifetime observations on mice subjected to skin painting of crude shale oils, oil shale and retorted shale solids. Evaluation of mutagenic activity was based upon microbial tests, mouse lymphoma assays and cytogenetic analyses in bone marrow of the rat. In the teratogenicity evaluation, pregnant rats were exposed to graded airborne concentrations of the test materials to determine if developmental anomalies resulted. Analytical testing, such as determining the free silica content and particle size distribution to assess potential inhalation exposure, was also conducted to characterize the shale materials. The results of this program have now been published and can be obtained from the API (Weaver and Gibson, 1979). RBOSC is currently encouraging the API to institute additional studies on Lurgi materials.

2. DOE Research Program - RBOSC has worked closely with the DOE task force to ensure a successful testing program and has provided, and will continue to provide, additional support and assistance in the following areas:

- Assisting in designing the program
- Expert support in developing appropriate testing protocols
- Supplying representative samples for testing
- Providing expert review and commentary on reports

The DOE toxicology studies are designed to characterize the materials produced by the MIS retorting process, evaluate the environmental transport, fate and hazard of these materials, and determine methods of controlling the exposure hazard.

TABLE 9-7-1

API SHALE TOXICITY TESTING PROGRAM

| Material | Location | Process | Acute | Carcino-genesis | Muta-genesis | Terato-genesis | Analy-tical |
|---|---|---|---|---|---|---|---|
| Raw Shale | Anvil Points | | X | X | X | X | X |
| Raw Shale | C-a Tract | | X | X | | | X |
| Raw Shale | White River | | X | X | | | X |
| Shale Oil | Parachute Creek | Tosco | X | X | X | X | X |
| Shale Oil | Anvil Points | Paraho | X | X | X | X | X |
| Shale Oil | Anvil Points | Paraho | X | X | | | X |
| Shale Oil | Parachute Creek | Union | X | X | X | X | X |
| Processed Shale | Parachute Creek | Tosco | X | X | | | X |
| Processed Shale | Anvil Points | Paraho | X | X | X | X | X |
| Processed Shale | Anvil Points | Union | X | X | | | X |
| Processed Shale | Parachute Creek | Union SGR | X | X | | | X |

Within the DOE program, tests will be conducted on the following MIS materials as they become available:

- Raw and retorted shale
- Product water
- Product oil
- Sludge
- Mine seepage water
- Raw product gases
- Ground water from perimeter wells
- Flared product gases
- Scrubber blowdown
- Fugitive gases and particulates
- Leachate
- Site air and ambient air

Studies will include testing of laboratory test animals to determine the effects of the following:

- Inhalation of various materials and gaseous effluents
- Ingestion of various materials
- Long-term chronic exposure

The proposed DOE sponsored toxicology testing program for Tract C-a is summarized in Table 9-7-2.

The simpler and more rapid tests will be applied first to determine which materials should be assayed by more extensive and more complicated bioassay systems. Initially, the whole sample, e.g., raw shale or retort water, will be assayed by the bacterial (Ames) tests, and, if positive, by tests using mammalian cell cultures; chemical fractionation will then separate chemical classes, e.g., organic bases or acids. The fractions will be tested again by the bacterial and mammalian cell tests and, if positive, they can be further fractionated and tested by the short-term (acute) whole animal tests.

Table 9-7-2

PROPOSED DOE TOXICOLOGY TESTING PROGRAM FOR TRACT C-a

| | In vitro | | | | | In vivo | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Chemical Character-ization | Ames | Chromo-somes | Mammal cells | Cyto-toxicity | Inhal-ation | SCE | Pre-natal | Acute | Skin paint |
| Liquids: | | | | | | | | | | |
| Oil | X | X | X | X | X | ?* | X | ? | X | X |
| Retort Water | X | X | ? | ? | X | | ? | X | X | |
| Mine Seepage Water | X | X | ? | ? | X | | ? | X | X | |
| Dewatering Water | X | X | ? | ? | X | | ? | X | X | |
| Scrubber Blowdown | X | X | ? | ? | X | | ? | X | X | |
| Leachate | X | X | ? | ? | X | | ? | X | X | |
| Sour Water Tank | X | X | ? | ? | X | | ? | ? | ? | |
| Solids: | | | | | | | | | | |
| Particulates | X | X | X | X | X | X | X | X | X | X |
| Scrubber Sludge | X | X | ? | ? | ? | ? | ? | ? | ? | ? |
| Raw Ore | X | ? | ? | ? | ? | ? | ? | ? | ? | ? |
| Processed Shale | X | ? | ? | ? | ? | ? | ? | ? | ? | ? |
| Gases: | | | | | | | | | | |
| Offgas | X | ? | ? | ? | ? | ? | ? | ? | ? | ? |

*To be determined after initial testing is completed.

Additional studies will be conducted as part of the DOE program to evaluate the environmental hazard and fate of MIS materials and the potential hazard associated with occupational exposure. RBOSC will work with the DOE task force to design a similar program for Lurgi materials.

3. RBOSC Program - RBOSC plans to conduct supplemental analytical and biological testing of Lurgi materials, products and by-products if results from API and DOE-sponsored programs are not timely or complete.

Analytical and physical testing proposed include determination of the following:

- Particle size, shape, hardness
- Density
- Ash content
- Extractable organics
- Trace metals
- Cyanide
- Phenols
- Priority pollutants (13 PNA's)
- Corrosivity
- Reactivity
- Ignitability
- Extraction procedure toxicity

Supplemental biological tests that are being considered include acute toxicity assays of materials inhaled, administered orally or applied to the skin, tests of mutagenic and carcinogenic properties, reproductive studies, and evaluation of ocular and dermal irritation and dermal sensitization resulting from exposure to various oil shale-related materials. The toxicological tests, test organisms or tissue cultures, and test materials proposed to be used in the assays are listed in Table 9-7-3.

These proposed tests will be conducted in replicate with strict adherence to quality control according to the proposed Good Laboratory Practices and Testing Standard developed by EPA (44 CFR Part 145, 44 CFR Part 91).

Table 9-7-3

PROPOSED SUPPLEMENTAL TOXICOLOGY STUDIES TO BE CONDUCTED BY RBOSC, AS APPROPRIATE PENDING THE ACTIONS TAKEN BY DOE AND API

| Test | Test Organisms of Tissue | MIS Retort Water | Raw Shale Dust | Lurgi Retort Water | Lurgi Processed Shale | Lurgi Light Shale Oil | Lurgi Middle Shale Oil | Lurgi Heavy Shale Oil |
|---|---|---|---|---|---|---|---|---|
| Salmonella/Mammalian - Microsome Mutagenicity Test | Salmonella bacteria | X | X | X | X | X | X | X |
| Mouse Lymphoma Forward Mutation Assay | Mouse lymphoma cells | X | X | X | X | X | X | X |
| Acute Inhalation Toxicity ($LC_{50}$) | Rats | | | | | X | | |
| Dermal Teratology Study | Rats and rabbits | | | | | X | X | X |
| Dermal Cytogenetics Study | Rats | X | X | X | X | X | X | X |
| Unscheduled DNA Synthesis | Rat liver cell cultures | X | X | X | X | X | X | X |
| Acute Oral Toxicity ($LD_{50}$) | Rats | X | X | X | X | X | X | X |
| Acute Dermal Toxicity | Rabbits | X | X | X | X | X | X | X |
| Occular Irritation Test | Rabbits | X | | X | X | X | X | X |
| Dermal Sensitization Study | Guinea pigs | X | | X | | X | X | X |
| Primary Skin Irritation | Rabbits | X | | X | | X | X | X |

Documents describing the RBOSC Toxicology Program will be assembled and submitted to the OSO as soon as these documents are available.

D. Results and Discussion

1. API Study - In the inhalation studies, rats and monkeys exposed to either raw or processed shale at 10 and 30 $mg/m^3$ each for 2 years showed no evidence of carcinogenesis or progressive fibrotic lung disease from either material. Dermal application of raw and processed shales resulted in no evidence of carcinogenicity when applied on mice at a dosage of 50 mg twice weekly for a lifetime (approximately 2 years). Similar tests using raw shale oil showed, however, that the raw oil was highly carcinogenic. Tests using refined and semi-refined products were initiated in August 1979. Results of these tests are not available presently but it is anticipated that the refining steps will significantly reduce the carcinogenic and toxic properties of the retort oil (Weaver and Gibson 1979).

Tests of raw and processed shale and crude shale oil to determine teratogenic effects on pregnant rats showed no deformities, although some fetal toxicity was seen in rats exposed to the higher dosages of crude retort oil tested.

All of the raw shale oil samples yielded positive results for mutagenicity in the bacterial assays (Ames test), were either weakly positive or negative for mutagenicity in the mouse lymphoma assay, and showed no mutagenic tendencies in the cytogenetic bioassay.

Results of the studies on acute toxicity, irritation and sensitization are summarized in Table 9-7-4. Histopathological studies of the test organisms exposed to toxic concentrations of crude shale oils revealed extensive liver damage resulting from both oral and dermal administration of the oil.

2. DOE and RBOSC Sponsored Studies - Although the API study provided valuable data, the only samples from Tract C-a were of raw shale. The DOE sponsored studies and the supplemental RBOSC toxicology investigations will provide more comprehensive and site-specific data for the MIS and Lurgi retorting technologies, but results will not be available in the near future.

TABLE 9-7-4

SUMMARY OF RESULTS FROM ACUTE STUDIES CONDUCTED BY THE API

| Test | Sample | # | Results |
|---|---|---|---|
| Oral $LD_{50}$ (Rat) | Crude Shale Oils | (4) | 8-10g/kg |
| Dermal $LD_{50}$ (Rabbit) | Crude Shale Oils | (4) | 5-20mL/kg* |
| Eye Irritation (Rabbit) | Crude Shale Oils | (4) | Minimal/reversible |
| | Oil Shales (Ore) | (3) | Negative |
| | Processed Shales | (4) | Irritating/reversible |
| Dermal Irritation (Rabbit) | Crude Shale Oils | (4) | 0.5g/72hrs. Abraided/unabraided |
| Sensitization (Guinea Pig) | Crude Shale Oils | (4) | |
| | Oil Shales (Ore) | (3) | Negative |
| | Processed Shales | (4) | |

*Not firmly established

Results of these and other toxicology and industrial hygiene studies on oil shale-related substances will be used to develop an industrial hygiene program and control technologies to mitigate or prevent potential health and environmental hazards.

Documents describing the RBOSC Industrial Hygiene Program will be assembled and provided to the OSO as soon as these documents are available.

## 7.2 RECLAMATION SUCCESS/EXPERIMENTAL REVEGETATION STUDIES MONITORING

### A. Reclamation Success

1. Objectives - Revegetation of areas disturbed in conjunction with RBOSC activities is accomplished as soon after disturbance ceases as practicable. Seeded areas are monitored in order to ensure that revegetation efforts are resulting in the establishment of a diverse, effective, and long-lasting vegetative cover.

2. Methods - Success of revegetation efforts is monitored along permanently established transects within seeded areas. Transects are placed during the first growing season after planting and are marked at both ends with rebar stakes. Aluminum marking tags identifying the transect number, as well as the beginning and/or end of the transect, are attached to these stakes. Transects are 50 m in length and are oriented such that typical vegetational coverage is sampled. Orientation of transects is perpendicular to the existing slope whenever possible.

Coverage of grasses, forbs, and shrubs is estimated annually within sampling frames (1 $m^2$) placed at five meter intervals along the transects. Placement of these frames is facilitated by stretching a meter tape between the stakes at either end of the transect. Sampling frames are sub-divided into five percent segments and coverage of individual species is estimated to the nearest one percent. Data are recorded on field data forms, which are formatted for direct computer entry.

Above-ground biomass is determined during the 5th and 10th growing seasons. After coverage estimates have been made, species are clipped at ground level, bagged, oven-dried at 105 C for 24 hours, and weighed using a dial-o-gram balance (± .1 g). In instances where individual species are not identifiable because of grazing or other reasons, plant materials are segregated by growth form for productivity determinations.

Reclaimed highwalls of the open pit will not be revegetated. These walls will consist of bare rock at approximately 1:1 slopes. Monitoring of these slopes via surveyed monuments will be initiated only if similar monitoring of the steeper, operational slopes indicates that unstable areas exist. Should post-mining monitoring be warranted, monitoring locations and frequency will be determined in conjunction with the OSO and CMLRB.

B. Experimental Revegetation

1. Objectives - Three study sites on Tract C-a are being monitored to investigate experimental revegetation techniques related to surface disturbance and use of an artificial soil profile for revegetation of processed shale (Figure 9-7-1). Two sites established in 1975 address species adaptability, mulch type, timing of fertilizer application, and slope aspect variables as they pertain to revegetation of disturbed areas on Tract C-a. The third site, established in 1976, is monitored to assess the effects of seeding rate, mulch type, and establishment of an artificial soil profile on revegetation of Tosco II retort processed shale.

2. Methods - Coverage of grass, forb, and shrub species is estimated each year on the three experimental revegetation plots. Treatment plots and permanent sampling locations within plots are identified with rebar stakes placed in the upper right hand corners of the plots and/or sampling locations. Aluminum tags attached to these stakes identify the plot number and treatment combination.

Coverage of planted and invaded species is estimated to the nearest one percent within sampling frames (1 $m^2$) placed adjacent to the permanent

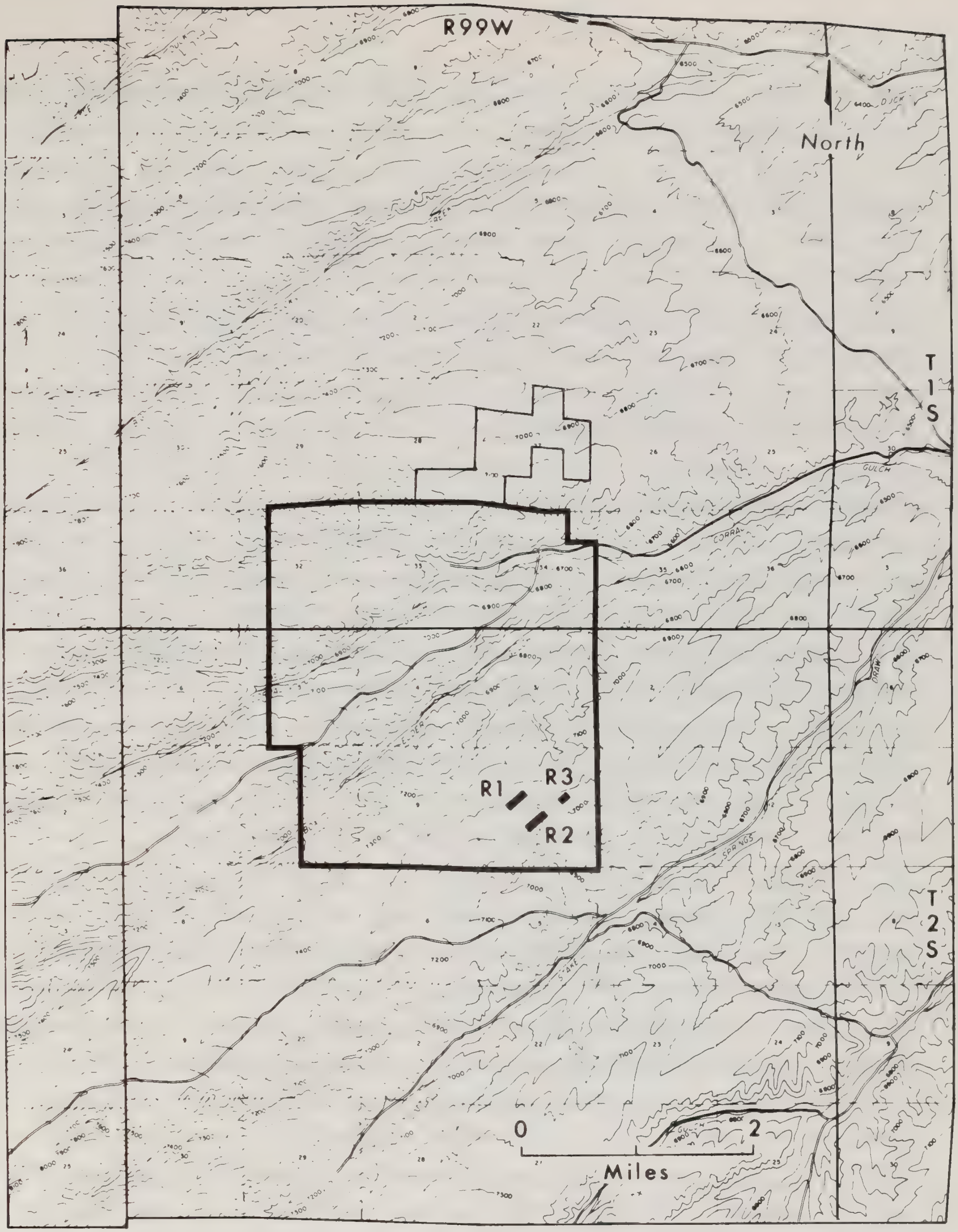



Figure 9-7-1
Experimental Revegatation Plots

marking stakes. Sampling frames are subdivided into five percent divisions to aid in these visual estimates.

Above-ground biomass is monitored on the three sites during the 3rd, 6th, and 10th years of growth. After coverage estimates have been completed, a sampling frame (1 $m^2$) without divisions is used to delineate the sample area. Individual species are then clipped, bagged, oven-dried at 105 C for 24 hours, and weighed on a dial-o-gram balance (± .1 g).

## 7.3 ECOLOGICAL INTERRELATIONSHIPS

The RBOSC environmental monitoring program is designed to provide a dynamic assessment of the Tract C-a ecosystem. In order to provide this type of assessment, data analysis techniques within each program will be reviewed and altered as conditions warrant to provide the flexibility necessary to keep the program sensitive to natural and man-induced environmental perturbations, changes in design plans and new found knowledge of the intricacies in the ecosystem. Analyses provided in this section are designed to provide information relative to the interrelationships among data collected in each monitoring program. These analyses will provide the necessary information required to make expert judgements on the interrelationships.

The control/treatment concept of sampling, used in each of the monitoring programs, will serve to identify and separate developmental impacts from natural variability in the ecosystem. Predictive testing and modeling will be applied to appropriate data sets whenever feasible in an attempt to identify future long-term impacts and recurring sequences of natural phenomena in the ecosystem. The use of sampling sites for collection of data on more than one parameter will allow direct comparisons of driving and state variables. Sampling bias will be avoided to the greatest degree possible and program elements will be altered as necessary to avoid sampling errors. Nonstatistical tests will be employed on low intensity data to supplement quantitative data where necessary.

Three categories exist in which interrelationships for the above sampling programs can be grouped. They are the abiotic-abiotic, abiotic-biotic, and biotic-biotic relationships. The analyses described for each of these categories will satisfy section 1(c)2(d) of the Environmental Stipulations accompanying the Tract C-a Oil Shale Lease, which requires the lessee to "...study, and report to the mining supervisor on ecological interrelationships..."

A. Abiotic Interrelationships - The following statement concerning abiotic interrelationships was made in a Tract C-b monitoring report: "Interrelationships among abiotic components and processes in the Tract C-b environmental system are important primarily because the abiotic portion of the system usually functions as a medium for transporting environmental perturbations between the source and the biota of the system. The most important media, of course, are air and water" (C-b Shale Oil Venture 1978). Naturally occurring relationships among abiotic components are not of direct concern in the assessment of the effects of oil shale development. It is important, however, to separate natural events from man-induced changes in order that the nature and extent of development-related impacts may be identified. A large number of abiotic interrelationships were identified for Tract C-a (RBOSP 1977). Some of the more significant of these are identified in Table 9-7-5.

The climatic factors of Tract C-a (e.g. rainfall events, snowfall, wind patterns, solar insolation) are not likely to be altered by development of Tract C-a. Therefore, changes in related abiotic components (surface water flows, ground water recharge and availability, etc.) which result from natural climatic variations cannot be attributed to development. The value of studying such relationships lies in being able to recognize natural variations and to distinguish these from man-induced effects.

Abiotic components which are subject to development perturbations include: ambient air quality, ground and surface water quantity and quality, soil erosion potential, slope characteristics and soil chemistry. Changes in ambient air quality can be expected as a result of emissions from stacks, vehicle and generator exhausts and vehicular movement. Introduction of contaminants into the atmosphere can potentially affect the quality of precipitation falling in the region. RBOSC has chosen not to attempt characterization of precipitation quality on Tract C-a. Data from other studies

TABLE 9-7-5

IMPORTANT TRACT C-a ABIOTIC INTERRELATIONSHIPS

Influence of precipitation on surface water (quality, quantity and velocity)

Influence of atmospheric contamination on the quality of precipitation

Influence of deep aquifer quality on alluvial aquifers

Influence of ground water quantity on surface water quantity

Influence of ground water quality on surface water quality

Influence of ground water flow/movement on surface water quantity and quality

Influence of ground water level on surface water quantity and quality

Influence of ground water availability/consumption on surface water availability

Influence of surface water flow on surface water sediment load

Influence of surface water flow on stream bed erosion

Influence of soil erosion on surface water sediment load

Influence of atmospheric contamination on soil chemistry

Influence of slope on drainage basin characteristics

Influence of slope on soil erosion potential

Influence of drainage basin on surface water flow and velocity

Influence of terrain stability on surface water sediment load (including stack sampling) will be used to determine if atmospheric contamination is significant. However, as industrial activity in the area increases, or in case of upset conditions, RBOSC may need to initiate precipitation quality sampling. Information from a variety of sources, e.g. ambient air quality monitors, water quality analyses and vegetation condition and soil chemistry data will be compared with contaminant release data to assess the need for additional sampling and analysis.

Effects on ground water quality and quantity are anticipated to result from development. Several components of the monitoring program are designed to measure these effects, including water quality of alluvial and deep oil shale aquifers, water levels in various aquifers and drawdown data (see Section 9, Chapter 6). In addition, modeling results will be used to further characterize these effects. Corresponding changes in surface water flows and quality due to changes in the ground water regime will be traced through collection and analysis of flow and quality data. A variety of data analysis techniques will be used to identify these relationships, including:

- Discriminant function analysis of chemical differences among the three aquifer systems
- Factor analysis of the chemical constituents in the three aquifer systems
- Time trend analysis of changes in water quality or quantity over time
- Correlation analyses of ground and surface water quality
- Correlation of surface flow with ground water usage

The soil stratum is another important abiotic environmental component that is likely to be affected by development activities. Potential effects include soil contamination from atmospheric release, increased erosion, changes in slope aspect and stability and changes in water holding capacity (and runoff). The occurrence of such effects will be tracked by collection and analysis of soils samples (when triggered by contaminant release data), aerial photography, turbidity measurements and sediment and runoff data. Soil sampling and analysis techniques will be evaluated to identify reported interactions of abiotic factors and soil characteristics. Analysis of these relationships will be performed when sufficient sampling bias can be removed from soil sampling techniques and data can be collected in sufficient numbers to provide meaningful examination of the data.

As the physical and water quality data from Tract C-a are evaluated and the interrelationships are more fully understood, data analyses techniques will be re-examined and adjusted as necessary to maximize the utility of the data.

B. Abiotic-Biotic Relationships - The following abiotic-biotic relationships in the Tract C-a area have been determined to be of primary importance (RBOSP 1977):

- Influence of precipitation quantity on vegetation production
- Influence of precipitation quantity on vegetation cover and density
- Influence of precipitation cycles on mule deer densities
- Influence of ambient air temperature cycles on mule deer densities
- Influence of slope/aspect on vegetation cover or composition

Aspects of the climatic regime which are of critical importance to plants and wildlife in the Tract C-a area include amount of rainfall and snowfall, length of the growing season, maximum and minimum temperatures and the frequency and velocity of wind (RBOSP 1977). However, RBOSC's activities on Tract C-a and the vicinity are not expected to appreciably affect any of these climatic factors. It is important, though, to be able to determine the influences of natural climatic variations on biotic components of the area and to be able to distinguish natural biotic variability from man-induced variability. Tracking of such interactions will be attempted through the use of analysis of variance, regression, trend analysis and graphical display techniques.

Changes in vegetation identified by study of aerial photographs may trigger additional phytosociological sampling to pinpoint the extent and type of change which has occurred. The source(s) of the change(s) will be investigated by comparison of baseline and monitoring data; review of development activities (e.g. dewatering, releases of air borne pollutants); consideration of wind patterns, climatic factors and regional effects; and comparison of control-treatment areas. Specific data analysis procedures will be designed after more information is available on the nature of the change and in accordance with the resolution of the data available.

Effects of precipitation events on mule deer abundance and distribution in the area may be difficult to assess because of the sporadic nature of area snowstorms and the resulting variation in accumulations of snow in the Tract C-a area. The relationships between these parameters will be established to the greatest extent possible by plotting mule deer pellet plot data on topographic maps and comparing these maps with snow depth data for the tract area. The relationship between mule deer use and vegetation type occurrence will be studied by plotting deer-use isopleths on vegetation distribution maps or photographs. Over time, changes in deer use should be discernible.

The failure of mule deer to utilize a given area will be studied by the following methods:

- Time series plotting of mule deer densities (by seasons) versus time over a period of years
- Cluster plots and analysis of mule deer densities by slope, aspect, vegetation type and elevation by seasons over a period of six years

In the event of discernible major changes in vegetative type distribution, a number of additional studies may be triggered. Among these are the following:

- Soil moisture studies
- Soil chemistry studies
- Analysis of trace metal content in plants from affected and control areas
- Additional small mammal and avifauna studies
- Additional range and browse utilization studies
- Additional deer density studies

Analysis and review of these and other data will aid in identification of the cause of noted changes. As expressed in the C-b developmental monitoring program, however, "Most of the abiotic effects impinging upon the biota of the environment....will be felt through interactions among the biota themselves. For example, disturbed vegetation associated with man's activities in the area will affect the general habitat of plants and animals. It is difficult to say at this time how widespread the effect would be or to what degree specific plants or animals would be affected." Therefore, an analysis of biotic interrelationships is an essential step in attempts to identify "causes" of these changes, as discussed in the following section.

C. Biotic Interrelationships - The biotic interrelationships on Tract C-a fall into two distinct ecosystem response units - the aquatic system and the terrestrial system. Interactions between the two systems are limited and difficult to identify or to test. Therefore, the interrelationships to be addressed during the Modular Development Phase will be limited to interactions among terrestrial biota and to those among aquatic biota.

Analysis of baseline data identified important interrelationships between terrestrial biota on Tract C-a and vicinity, including:

- Predator-prey relationships
- Food availability and animal abundance, behavior and distribution
- Cover (habitat) condition in relation to animal survival and population increase or decrease

Environmental data collected during the monitoring program will be evaluated to quantify these relationships, where possible, and to identify the significant components of each interrelationship for the ecosystem of Tract C-a and vicinity. If components can be adequately identified, the monitoring program will be adjusted to provide more meaningful data. Caution must be exercised, however, so that premature and/or incorrect conclusions regarding "cause" for apparent changes in such relationships are not drawn.

Food is the single most important ecosystem component regulating the survival and success of animal populations. In the case of carnivores, the availability of prey determines the presence of absence of the predator. For foraging animals, the condition or productivity of the vegetation is most important.

Unfortunately, predator-prey relationships are particularly difficult to quantify because of the difficulties in determining population status of either the predator or the prey. The coyote census conducted during baseline studies failed to provide accurate information on populations of this predator in the area. This was also true for other major predators. As a result, quantitative predator-prey studies are not planned for the MDP monitoring program. Qualitative data will, however, be available, including field notes relating to rabbit and coyote sightings in the area, raptor sightings, road kill counts and other similar data. These qualitative data will be used by the Tract C-a field biologist during assessments of development impacts and while preparing reports on the status of the tract environment to complement other, more quantitative data.

Availability of forage will be determined by a number of techniques including aerial photography, analyses of range condition and utilization, analyses of browse condition and utilization, photo plot studies and phytosociological studies. Data from these studies will be compared with forage animal data (e.g. mule deer density, cattle allotments, small animal data) to characterize the terrestrial response units of the ecosystem.

Analyses will include the following:

- Clustering techniques to examine browse type availability and mule deer densities
- Spectral analysis of mule deer densities and browse availability and utilization over time (a minimum of six years data is required for an accurate assessment using this technique)
- Trend analysis of mule deer densities versus browse utilization over time

Although it would be interesting to conduct similar analyses for other animals (e.g. small mammals and birds) RBOSC does not anticipate that available data will be adequate to justify such comparisons. The data will be evaluated, however, to ascertain suitability for additional analyses. If they are suitable, similar analyses will be completed.

Since vegetation production is closely related to cover, many of the analyses just described will provide insight into the relationship of habitat condition and animal survival and success. These analyses, coupled with surveillance of discrete habitat changes and animal behavior, will help answer questions related to these interrelationships.

The analysis of aquatic ecosystem responses will be directed toward the two most significant components of that ecosystem - the periphyton and benthos communities. Baseline studies have indicated that these two groups significantly impact one another. Periphyton serves as a major source of food for the benthic community and therefore limits and is limited by the benthic component. A series of analyses will be carried out to further define the interrelationship of these two groups:

- Comparison of relative numbers of periphyton and benthos in similar locations over time
- Correlations of species diversities of each group with baseline values
- Time series graphs illustrating the fluctuations in species diversity and relative abundance over time as development proceeds

D. Summary - As more data are collected and analyzed, additional insight regarding the function of various components of the ecosystem will be gained. With time, the sampling program and the analyses will be modified to maximize the usefulness of this newly acquired knowledge. RBOSC will not be able to answer all the questions that will be asked about the terrestrial and aquatic ecosystems in the Tract C-a area during the life of this project. RBOSC should be able, however, to add a great deal of information to the existing data base, which will aid researchers, regulatory agencies and industry in the environmentally sound development of the oil shale region.

## 7.4 RUN-OF-MINE ORE STOCKPILE LYSIMETER STUDY

RBOSC has agreed to conduct leaching studies on MIS stock-piled run-of-mine ore in cooperation with the EPA, USGS and the DOE Task Force. As a part of this agreement, RBOSC constructed the leaching apparatus in the stockpile. The cooperating government groups will collect and analyze the leachate.

The collection system consists of three collectors buried beneath the raw shale pile at depths of 5, 10 and 15 feet. Each collector consists of a 10x10 foot square teflon sheeting, contoured so that the percolation is intercepted and conducted to a teflon drain pipe located at the center of the collector. (Figure 9-7-2). Leachate is then diverted to a series of teflon collection bottles (Figure 9-7-3) housed in a wooden shelter.

A flow-through electrical resistance probe and a thermocouple has been placed in the teflon collection line to measure conductivity and temperature. Recording rain gages document precipitation quantity in the area of the pile. Snow depths are periodically recorded.

Samples are collected by the USGS after a precipitation event and split for distribution to the involved researchers. Analyses are then analyzed for the constituents indicated on Table 9-7-6. Results are reported as available by RBOSC in the semi-annual reports.

The lysimeter will be maintained for at least three years. The program was initiated in the spring of 1980.

## 7.5 SEDIMENT CHARACTERIZATION STUDIES

Samples for sediment characterization studies will be collected upstream from USGS Gaging Stations H and D (See Figure 9-6-1). Sediment samples will be collected during a low flow period, during a time which coincides with one of the other monitoring program water quality sampling periods.

Samples will be collected using a BMH-53 sediment sampler or equivalent. Only the upper inch of sediment will be retained for analysis. A minimum of six samples per site will be collected. From these individual samples, a composite sample for each site will be prepared. These composite samples will be stored for later analysis, the details of which will be developed in cooperation with the OSO and the DOE Oil Shale Task Force.

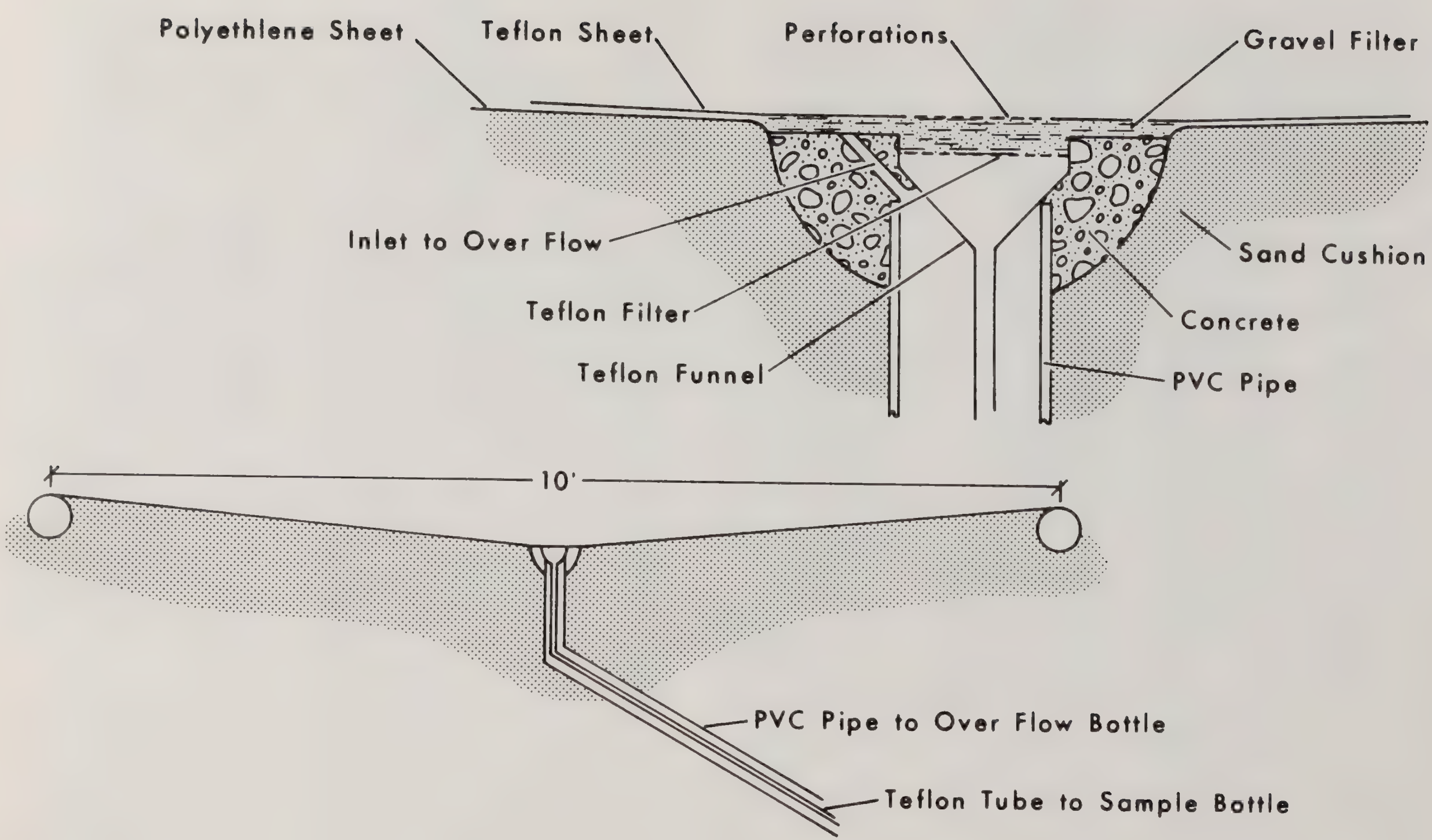



Figure 9-7-2
Construction Details of the Buried Collectors - Tract C-a

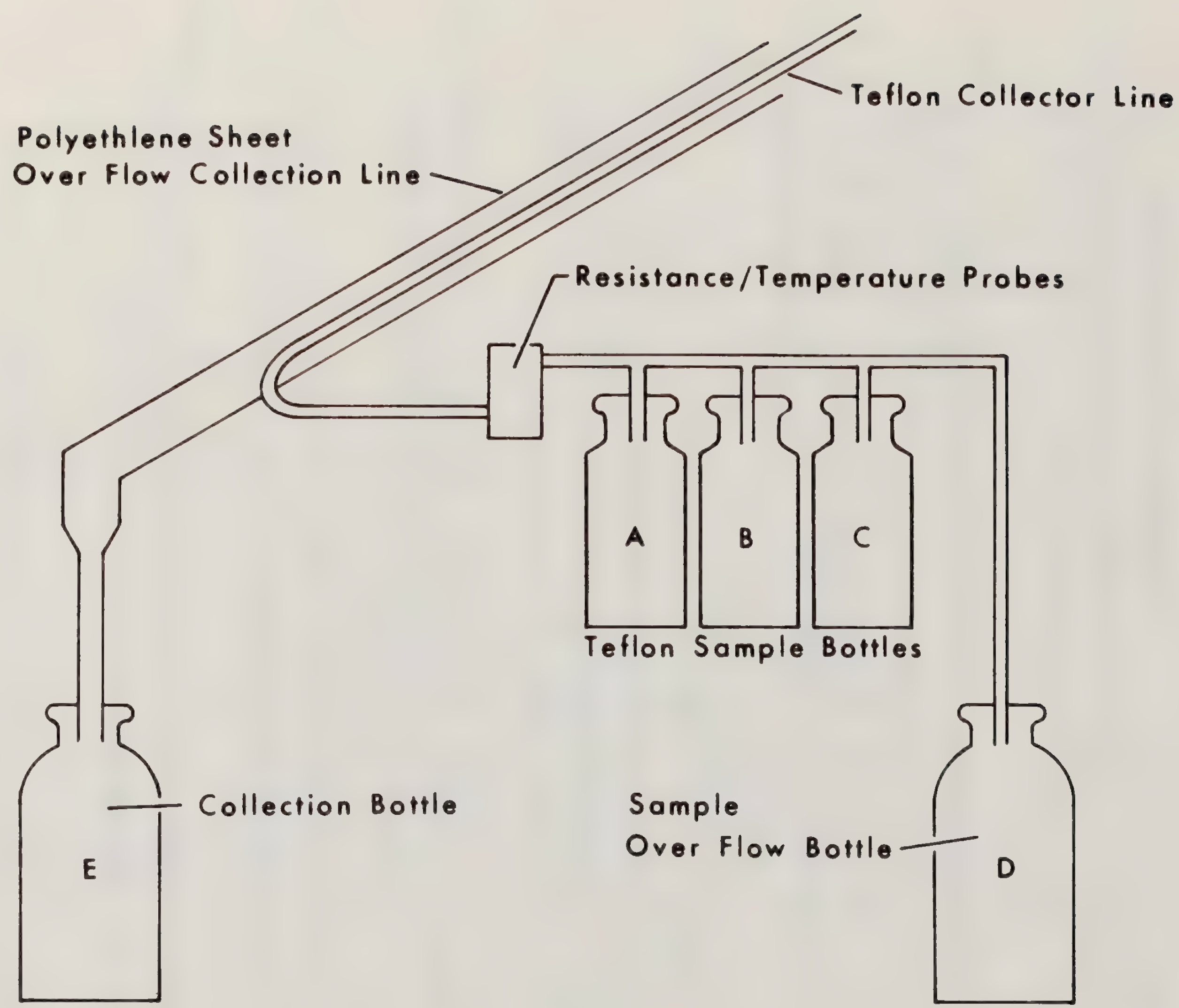



Figure 9-7-3
Schematic of the Collection Bottle Arrangement

TABLE 9-7-6

RAW SHALE LYSIMETER, TRACT C-a

ANALYTICAL SCHEDULES AS OF 7/20/80

| Investigation - Lab | Constituents to be analyzed |
|---|---|
| Field | T,EC (electrical conductivity), pH; DO & Total Alkalinity, if sample volume permits. |
| McWhorter - CSU | Comprehensive list[1/]: Al, Ammonia, As, Asbestos, Ba, Be, $HCO_3$, B, Cd, Ca, $CO_3$, Cl, Cr, Co, Cu, CN, F, Fe, Pb, Li, Mg, Mn, Hg, Mo, Ni, $No_3$, Tot N, $PO_4$, Tot Phos., K, Se, $SiO_2$, Ag, Na, Sy, $SO_4$, Sulfide, Tl, Thiosulfate, Sn, Ti, U, V, Zn, Alk, ec, pH, TDS, DO, T, DOC Fractionation. |
| | Routine list[2/]: Na, Ca, K, Mg, $HCO_3$, $CO_3$, Cl, $SO_4$, B, F, Al, MO, $SiO_2$, Thiosulfate, Se, Alk, ec, pH, TDS, DO, T, Zn, DOC Fractionation. |
| USGS-WRD-OSO | Ca, Mg, Na, K, $HCO_3$, $CO_3$, $NO_3$, $SO_4$, Cl, $SiO_2$, F, B, Phenols, Tot P, Mn, Fe, As, Ba, Be, Cd, CO, CU,Pb, Li, Mn, Mo, Sr, V, Zn, Ni. |
| Leenheer - WRD | DOC, DOC Fractionation, selected specific organics. |
| Wildung - DOE-OSTF | Redox, participate with McWhorter-USGS in replicates, reduced sulfur species (mostly in field). |

1/ Initial samples, schedules frequency to be determined as findings progress during the experiment.

2/ Analyses to be run on samples A-D from each lysimeter, unless findings dictate differently.

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